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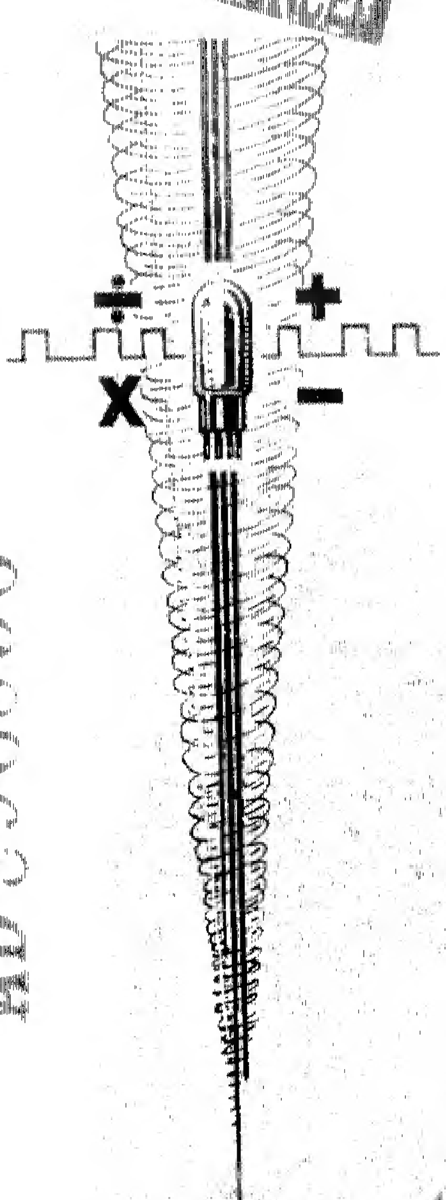
PROJECT
WHIRLWIND

Contract N5ori60



SUMMARY REPORT NO. 2

VOLUME 16

VACUUM TUBES

SERVOMECHANISMS LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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SPECIAL DEVICES CENTER

UNANNOUNCED

(1)

PROJECT WHIRLWIND
Summary Report, No. 2,
November, 1947

VACUUM TUBES.

Volume 16 of 22 Volumes

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

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CONTENTS (Contined)

INTRODUCTION

The two basic elements of the block diagrams of the Whirlwind computers, e.g., the block diagram of the accumulator ~~(Vol. 6, Fig. 65)~~ are the flip-flop circuit and the gate circuit, symbol GT. These two elements need not necessarily employ vacuum tubes, since other non-linear components exist which might possibly be used. However, in Whirlwind I, two pentodes and a pentode trigger tube will be used for each flip-flop and a pentode gate tube will be employed in each gate circuit.

Vacuum tubes are also used for certain special functions in the computer, such as the sine-wave oscillator or the pulse generator in the master clock. In addition, vacuum-tubes must be used as power amplifiers in places where a pulse is to be generated across a low impedance. (Gas tubes will not be used in any of the high-speed circuits, as their deionization time prohibits their use. However, neon lamps will be used as indicators on all flip-flops and a thyratron may be used in the push-button-pulse generator).

The total number of tubes for Whirlwind I is given in M-132 of this volume along with a breakdown of the number of tubes for each function. Of a total of 3500 tubes, 1150 are used in gate tube, or time-coincidence circuits, 700 are used in flip-flop circuits, and 870 are used as buffer amplifiers. Memorandum M-131 lists the tube types used for these different functions and explains why the particular types were selected for Whirlwind I.

The tube used in flip-flop circuits and for many buffer amplifiers is the 6AG7. The average characteristics of this tube are given in R-118. Life tests of the 6AG7 are described in M-119 and M-128; a photograph of the life-test rack is shown in FB-291.

Until recently, the only gate tube available has been the Western Electric 6AS6. This tube has proven unsatisfactory at the pulse-repetition frequency and with the pulse shape used in the Whirlwind computers as explained in M-80. For a time,

an attempt was made to use the 6AS6, since no other gate tube was available. This is described in R-104, E-50, E- 61 and M-103. However, a special gate tube was developed by Sylvania, (Sylvania type No. SR-1030), and use of the 6AS6 was abandoned. See M-80, M-81, M-82, M-83, M-103, M-109, M-118, M-116 and E-73.

Characteristics of neon lamps are presented in R-117 and M-72.

Photograph FB-302 shows the new Sylvania gate tube, SR-1030.

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MEMORANDUM NO. M-[illegible]

SERVOMECHANISMS LABORATORY
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO: 6345 Engineers 6345

FROM: Louis D. Wilson Page 1 of 3 pages

SUBJECT: Gate Tubes in WW1

DATE: June 6, 1947

In the preliminary design and experimental work connected with WW1, it has become increasingly evident that the systems of gating which are at present available are inadequate and represent one of the most serious limitations in the solution of the circuit problem.

The problem has not as yet been satisfactorily solved by the use of any of several methods. At present it seems that steps should be taken to obtain a tube more suitable for the applications which we have in WW1.

Some of the troubles encountered in two of the methods used to date are listed below.

1. METHOD I, 6AS6 GATING

Digits on control lines will be at a power level of about 2 to 6 watts (15 to 25 volts) at 100 ohms impedance level. After passing through a 6AS6 gate tube these signals will be attenuated to about 0.2 watts (15 volts) at 1000 ohms impedance level. Wherever it is necessary to continue the path of this signal, a buffer amplifier is needed to get back to the 100 ohm level at the 2 to 6 watt power level. Even this addition is not very satisfactory since the output of the gate is not enough for reliable off-on operation of the buffer and the buffer introduces additional delay and reduces bandwidth.

In some instances it is possible to utilize a delay line as a means of transferring a signal from one part of the system to another at 1000 ohms impedance level. The 6AS6 will provide the needed signal at this impedance level by driving Grid No. 1 and Grid No. 3 positive. Just how this treatment effects tube life is not known at present but there are indications that life will be reduced. It is highly desirable to use A.C. coupling in as much of the computer as possible (See Memorandum No. M-77). If the 6AS6 is used with the gate A.C. coupled to the suppressor, the requirements for the coupling circuit are complicated by the fact that the suppressor must be driven about five volts positive to obtain the needed output. If the No. 1 grid is used to avoid these coupling problems, the No. 2 (screen) grid has to be run above rated dissipation

to obtain output required, and so the tube again is a limiting factor.

2. CATHODE GATING USING 6AG7'S

By connecting 2, 6AG7's thru a common cathode resistor, it is possible to use a positive gate signal on the grid of one as a means of biasing the other 6AG7 beyond cutoff, and effectively closing the gate to signals. In the absence of positive gate signals the second 6AG7 conducts and passes the digit applied to its own grid. This system definitely eliminates the need of the buffer and maintains impedance levels at about 100 ohms. However, complications arise here in that the common cathode resistor in parallel with the output impedance of the gating tube acts as a negative feedback path to digits when the gate is open. This feedback reduces the gain of the gate.

By-passing this resistor is effective in eliminating the feedback but causes sluggish rise time on the gate which is objectionable. A scheme of avoiding this difficulty has not been found.

3. CONCLUSIONS

At present work is proceeding along the lines of utilizing the 6AS6 and getting around the associated problems. It is felt, however, that a better tube should be obtained for gating so that future work will not continually be hampered by the gating problem.

The specifications for such a tube are attached. This tube should be designed for long life (of the order of 10,000 hours) and must be adaptable to standard mass production methods.

The electrode dissipations indicated are based on the premise that the tube will be operated with actual dissipations equal to one-half these rated values in order to increase tube life.

Louis D. Wilson
Louis D. Wilson (s)

LW:has

6345
Memorandum No. M-80

Specifications for Desired Gate Tube

Heater - 6.3 volts

Maximum Ratings (Design-center values)

Maximum Plate voltage	350 volts
Maximum Screen voltage	250 volts
Maximum Plate dissipation	12 watts
Maximum Screen dissipation	2.4 watts
Maximum Average Cathode Current	100 milliamperes
Maximum Heater-Cathode voltage	100 volts

Operating Characteristics

Plate voltage	150	150	150	volts
Screen voltage (Grid No. 2)	100	100	100	"
Suppressor voltage (Grid No. 3)	0	-8	0	"
Control grid voltage (Grid No. 1)	0	0	-8	"
Plate current	40 (min.)	1 (max.)	1 (max.)	milliamperes
Screen current	10	40 (max.)	1 (max.)	milliamperes

Interelectrode Capacitances

Input	7 μμf Max.
Output	4 μμf Max.

LDW:has

MEMORANDUM NO. M-61

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO: Jay W. Forrester, H. R. Boyd, R. R. Everett, H. Fahnestock, N. H. Taylor — 6345

FROM: D. R. Brown and L. D. Wilson —

SUBJECT: Trip to Sylvania at Emporium to Initiate Development of Gate Tube

ENCLOSURES: A. Tentative Specifications - WWI Computer Switch Tube.

DATE: June 11, 1947

The Sylvania tube plant at Emporium, Pa., was visited by Brown and Wilson of M.I.T., and Moses of Sylvania, Boston, on June 9, 1947.

A meeting to discuss the proposed tube was held in the office of Mr. Walter R. Jones. Those present were:

Mr. David R. Brown, M.I.T.

Mr. Walter R. Jones, Chief Engineer of Sylvania's Radio Division

Mr. Monte Kiser, Chief Tube Design Engineer

Mr. Robert C. Moses, Sylvania, Boston

Mr. Eugene E. Overmier, Chief of Commercial Engineering Section

Mr. Louis D. Wilson, M.I.T.

The specifications for the proposed gate tube, prepared by Moses from our original specifications, were presented to the group. These specifications are listed in Enclosure A.

Mr. Kiser felt that a tube could be designed to meet the specifications without much difficulty. A pentagrid tube would probably be the best approach. However, both a pentagrid tube and a pentode, a larger version of the 6AS6, would be designed. The pentagrid tube could be gated without driving the gating grid positive and be more desirable than the pentode. The pentagrid tube would also have lower grid-to-plate capacitance. Design will probably start with the structure of the 7W7 or some similar tube. Mr. Kiser

felt that the specified capacitances, especially the output capacitance, would have to be increased. Also, the screen dissipation may have to be increased. Loctal construction will be used unless we specify some other type.

Mr. Kicer stated that our specifications could be met after three or four preliminary designs had been built and tested. The samples of the first preliminary design will be sent to Sylvania, Boston, about August 1. When the final design is obtained, a lot of several hundred tubes will be produced and complete measurements will be made on all tubes. These measurements will be a check on the design to make sure that all the factors are under control. Measurements will be made by the Commercial Engineering section.

The earliest date at which production lots can be expected is September or October. December is believed to be a more reasonable date for production lots. Three months will be required for permanent tooling.

Emporium is willing to undertake the job on its own and prefers to work without a contract. The design will begin immediately.

Mr. Mayberry conducted us on a tour of the plant which showed all stages of tube production. Later, Mr. Overmier showed us the Commercial Engineering Department, including the test equipment available for measurement of tube characteristics, life, etc. In addition to equipment for measuring static characteristics by the usual point-by-point method, the department also has a dynamic characteristic viewer which shows the desired characteristic on a cathode-ray tube which may be photographed. Characteristics may be obtained in regions where power dissipation prohibits measurement by the point-by-point method.

Those we talked with at Emporium showed a high degree of understanding of the problems involved in pulse operation of tubes and a willingness to help us wherever possible. Sylvania is making tests to determine the effects of pulse operation on tube life and, in some cases, can predict tube life under pulse conditions. They believe that screen grids should be constructed to operate at the plate-supply voltage and that screen dissipation is often the limiting factor in pulse operation. Also, a higher screen voltage makes a larger grid-cathode spacing possible. Sylvania has found that tubes having high d-c emission have poor emission-life under pulse conditions. For long-life application, they feel that several hundred hours preaging is desirable and they are preaging tubes for one customer at the present time.

Loctal construction is believed to be superior to other types because of reduced interelectrode capacitance, lead inductance, and production cost and increased ruggedness and heat dissipation. Glass envelopes are preferred over metal because they hold their vacuum and dissipate heat better.

The Sylvania 7F8 was suggested as a substitute for the 2C51 and 12AU7 for twin-triode applications.

David R. Brown
David R. Brown

Louis D. Wilson
Louis D. Wilson

DRB:LDW:has

6345
Memorandum No. M-81

ENCLOSURE A

TENTATIVE SPECIFICATION - WWI COMPUTER SWITCH TUBE

Operating Conditions

E_{bb}	150 volts	
E_{c2}	100 volts	
D_p	6 watts	(12 watts maximum ratings)
D_{sg}	1.2 watts	(2.4 watts maximum ratings)
C_{in}	7 μμf	
C_{out}	4 μμf	

E_{c1}	E_{c3}	I_b
0	0	Not less than 40 ma
0	-8	Not greater than 1 ma
-8	0	Not greater than 1 ma
-8	-8	Not greater than 1 ma

Condition I.

E_{bb}	150	
E_{c2}	100	
E_{c3}	0	
E_{c1}	0	-8
I_b	40 ma	$<$ 1 ma
I_{c2}	8 ma	$<$ 1 ma
D_p	6.0 watts	
D_{sg}	0.8 watts	

Tentative Specification - WWI Computer Switch Tube

Condition II

E_{bb}		150
E_{c2}		100
E_{c3}		0
E_{c1}	-8;	8 volt positive pulse, rep. rate 1 Mc; duty cycle 0.25
I_b		40 ma peak
I_{c2}		8 ma peak
D_p		1.5 watts average

CONDITION III

E_{bb}		150
E_{c2}		100
E_{c3}		-8
E_{c1}	-8;	8 volt positive pulse; rep. rate 1Mc; duty cycle 0.25
I_b		$<$ 1 ma
I_{c2}		48 ma peak
D_{sg}		1.2 watts average

Life-Test Conditions

E_{bb}	150 $\pm$ 3 volts	150 $\pm$ 3 volts
E_{c2}	100 $\pm$ 2 volts	100 $\pm$ 2 volts
E_{c1}	0	-15 v; 15 volt positive pulse; duty cycle 0.25
E_{c3}	0	-15
I_b	40 ma	
I_{c2}	8 ma	48 ma peak
End Point	I_b $\leq$ 28 ma	I_{c2} $\leq$ 33 ma peak

DWB:LDW:hss

MEMORANDUM NO. M-82

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO: Jay W. Forrester, H. R. Boyd, R. R. Everett, D. R. Brown, N. H. Taylor, L. D. Wilson — 6345

FROM: H. Fahnestock — Page 1 of 1 page

SUBJECT: Sylvania Vacuum Tube Development

REF: Memorandum M-81

DATE: June 12, 1947

Following Brown's and Wilson's trip to Emporium, a meeting was held in Building 32 attended by Moses and Stevens of Sylvania. Moses said that M-81 correctly states Sylvania's position but in view of vacation schedule, the August 1st date for a sample tube appears optimistic by two weeks. Sylvania's Boston Division is conferring with Emporium to determine our approximate cost of the new tube after development which they are doing on their own.

Sylvania was instructed that the prospect of the new tube was in no way to affect the design and construction of the five-stage multiplier now under development.

Some slight objection to the lock-in base was raised by 6345 members but it was agreed the lock-in was certainly superior to miniature. Consequently, the base discussion should not affect the possible substitution of 7F8 for 12AU7 and 2C51 or the use of the proposed new tube in place of the 6AS6. If the new tube can be used in place of the 6AG7, the question is relevant. Sylvania much prefers the lock-in. They will make the sample tubes with lock-in base. If we later demand octal, they can add it at the expense of some tooling and several weeks delay in production.

We raised objections to the familiar unbalance in the two halves of 7F8's. Moses admitted this in the early tubes (1945) but said they are now made to JAN specifications which are much tighter. We will investigate JAN 7F8's and endeavor to establish unbalance tolerances for our uses. Sylvania is in a position to supply selected tubes to closer than JAN specifications.

H Fahnestock

H. Fahnestock

HF:has

MEMORANDUM NO. M-83

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO: J. W. Forrester, H. R. Boyd, D. R. Brown, R. R. Everett, N. H. Taylor, L. D. Wilson

6345

FROM: H. Fahnestock

SUBJECT: Gating Problems and Proposed Tube

DATE: June 20, 1947

A meeting was held on June 18 to acquaint Mr. Forrester with the subject matter and establish a policy thereon. The subject was discussed in the light of Memorandums M-80, M-81, and M-82. Conclusions were as follows:

1 - In order to use the proposed Sylvania gate tube in WWI, we must commit ourselves to it about the end of September, be assured of large quantities in March, and production of the tube such as to guarantee availability of replacements for several years to come.

2 - For the present all design will be on the basis of 6AS6 and 6AG7 tubes and active efforts will be made to improve circuits for their use.

3 - As stated in M-82, the prospect of the new tube is not to affect the design or construction of the 5-digit multiplier.

4 - In future layouts and designs we will bear in mind their adaptability to conversion to use of the proposed tube.

5 - Our attitude toward Sylvania will be that we will use the new tube if it is satisfactory and meets the requirements of (1) above.

H. Fahnestock

H. Fahnestock

HF:has

6345
Report No. R-104

SERVOMECHANISMS LABORATORY
Massachusetts Institute of Technology
Cambridge, Massachusetts

Date of Report: July 30, 1946

Page 1 of 3 pages

Written by: Robert H. March

Subject: Static Characteristic Curves for Western Electric 6AS6 Vacuum Tube.

Drawings:	Curve:
A-38128-G	I_B vs. E_{C1} (E_{C3} = 0)
A-38129-G	I_B vs. E_{C1} (E_{C3} = +10)
A-38130-G	I_B vs. E_{C3}
A-38131-G	I_{C2} vs. E_{C3}
A-38132-G	I_{C3} vs. E_{C3}

Reference: All data for curves can be found in 12RH:37-44.

Purpose of Test: To supplement published data.

Conclusions: Of the six tubes used in taking this data, Tube No. 6 was found to be average tube. No control-grid current was indicated when E_{C1} was varied from -20V to 0 or when E_{C3} was varied from 0 to +20V with E_{C1} zero. Table 1 lists for each tube, the control-grid and suppressor-grid cutoff voltage and the plate current with E_{C1} zero. The cutoff voltage for the six tubes tested varied as follows: With E_{C1} at zero, E_{C3} cutoff voltage varied from -7 to -10 volts. With E_{C3} at zero, E_{C1} cutoff voltage varied from -5 to -8 volts. With E_{C3} at +10 volts, E_{C1} cutoff voltage varied from -5 to -8 volts.

Technician: Robert H. March

Approved by JWF

RHM:bas

TABLE 1

$E_b = 150V$ $E_{c2} = 100V$ $E_f = 6.3V$

TUBE NO	E_{c3} CUTOFF $E_{c1} = 0$	E_{c1} CUTOFF $E_{c3} = 0$	E_{c1} CUTOFF $E_{c3} = +10V$	I_b $E_{c1} = 0$ $E_{c3} = 0$	I_{c2} $E_{c1} = 0$ $E_{c3} = +10V$
1	-10V	-8V	-8V	9.5 ma	11.8 ma
2	-10V	-6V	-6V	8.2 ma	10.2 ma
3	-7V	-5V	-5V	7.7 ma	9.6 ma
4	-10V	-5V	-5V	8.5 ma	11.2 ma
5	-7V	-6V	-6V	8.5 ma	11.6 ma
6	-10V	-6V	-6V	8.4 ma	11.5 ma

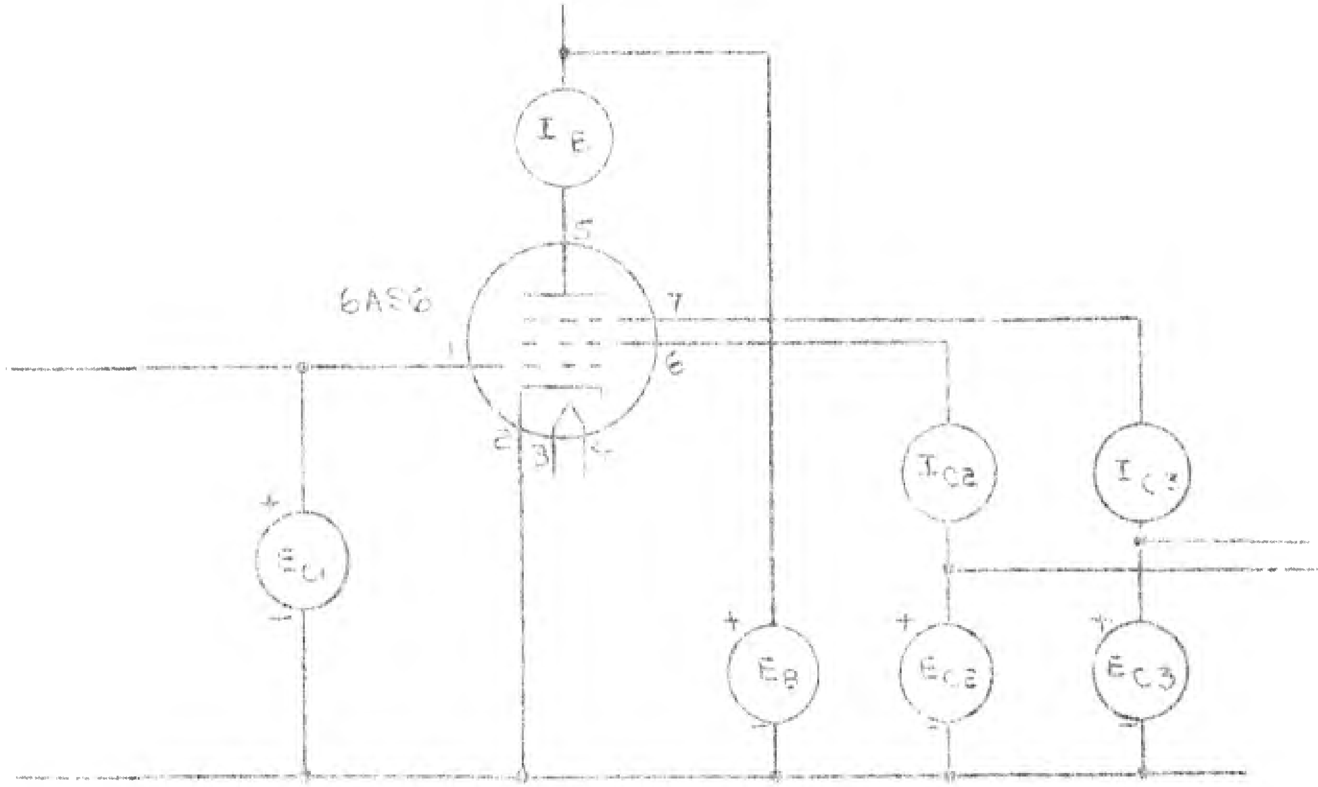


FIGURE 1
TEST CIRCUIT

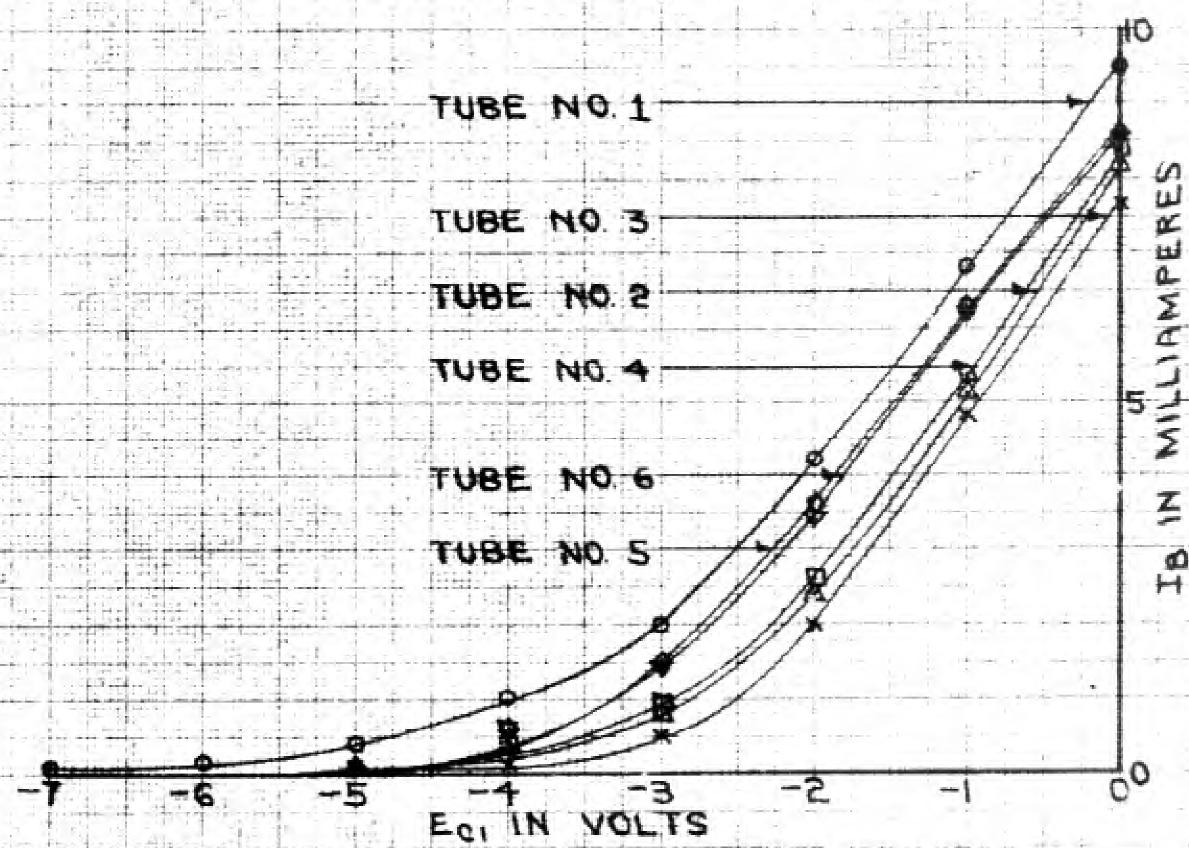
-38128-G

USED IN 6345 REPORT R-104

GAS6 STATIC CHARACTERISTICS
(I_B VS E_{c1})
($E_{c3}=0$)

$E_B=120V$
$E_{c2}=100V$
$E_f=6.3V$
$E_{c3}=0$

DATA FROM IRHM 37-44
MEASURED BY RHM
TESTS MADE 7/11/46
ENGINEER IN CHARGE: DRB



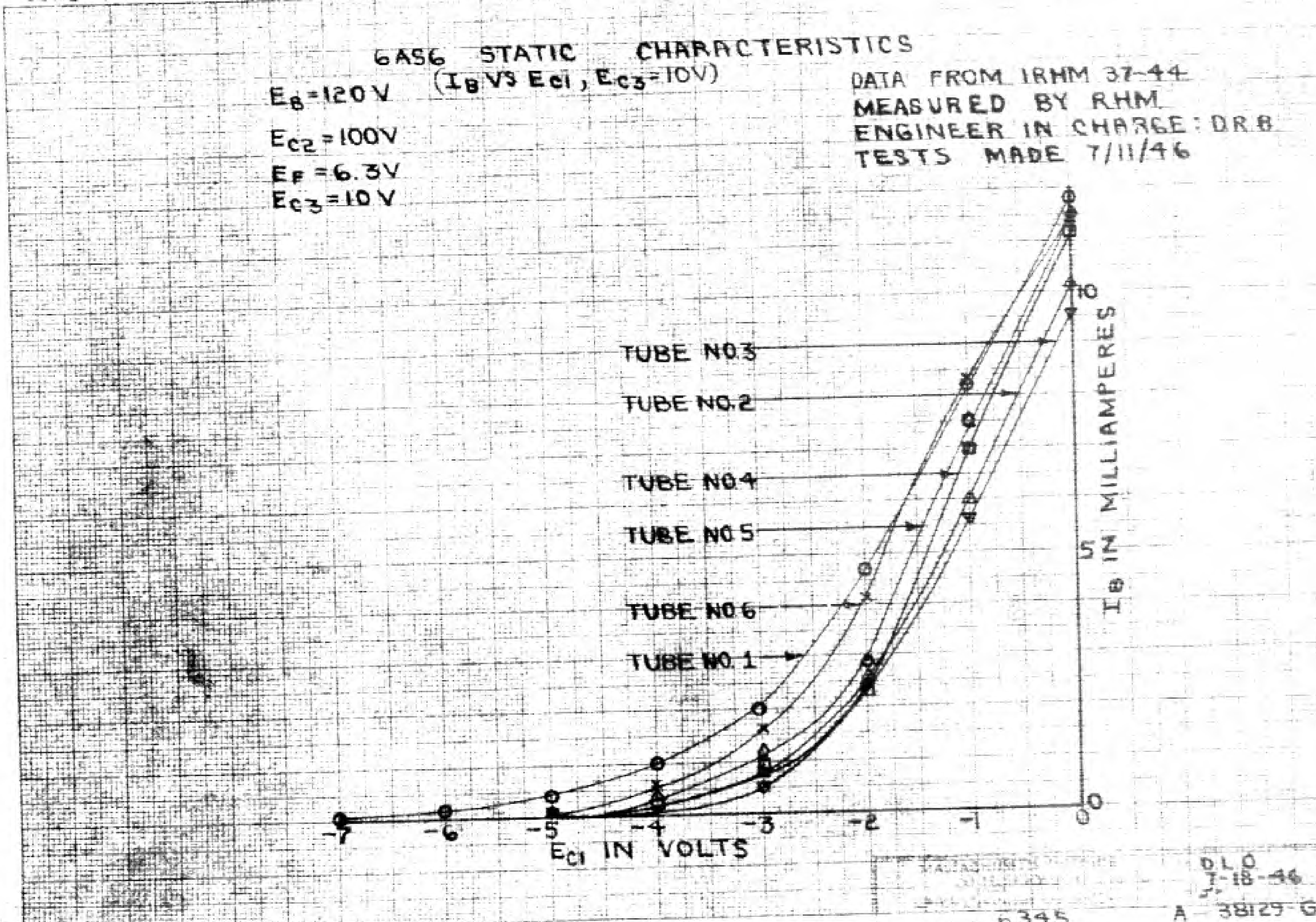
D.L.O.
7-18-46

6345

A--38128-G

1-38129-G

USED IN 6345 REPORT R-104

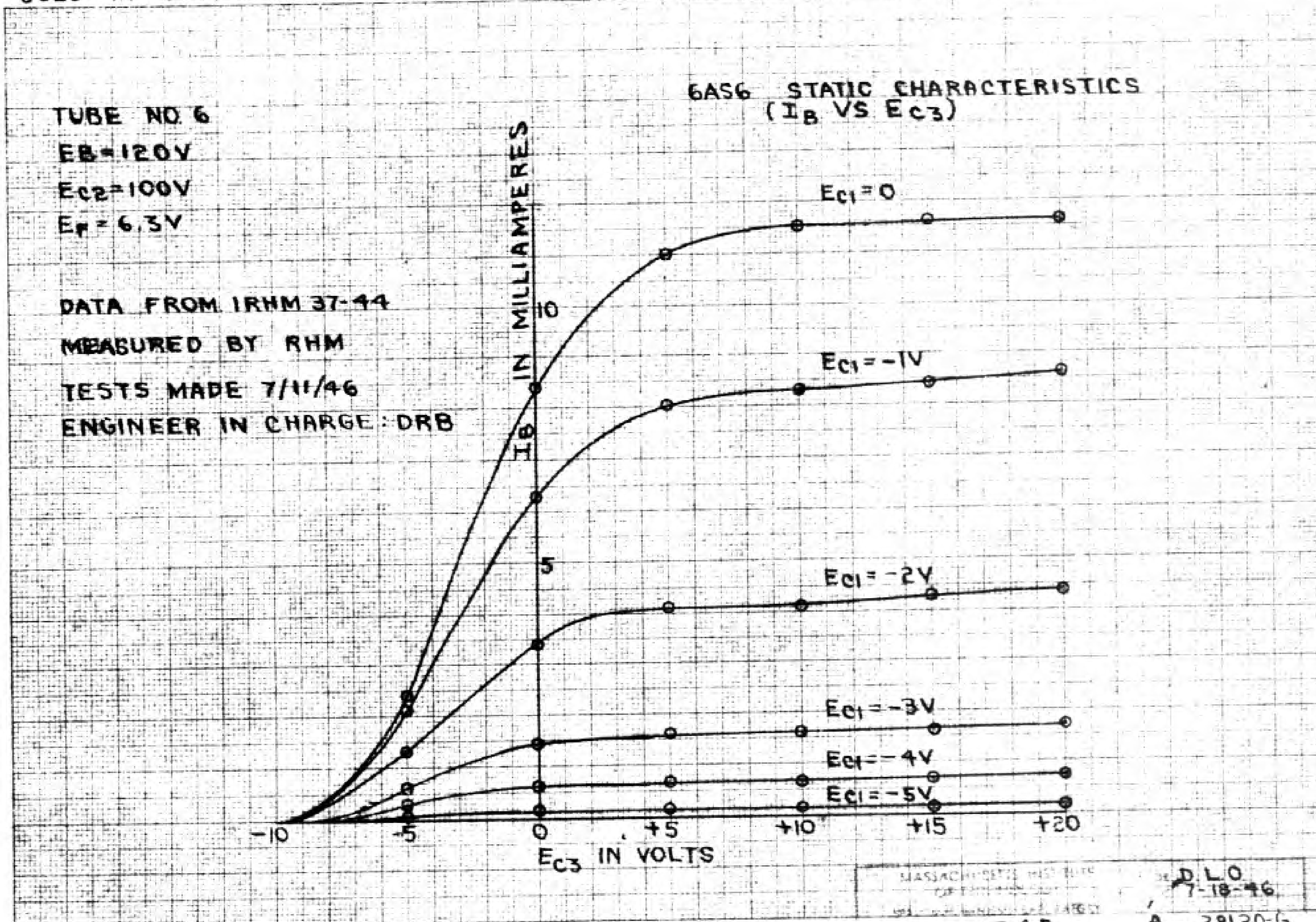


6345

D.L.O.
7-18-46
A 38129-G

-38130-G

USED IN 6345 REPORT R-104



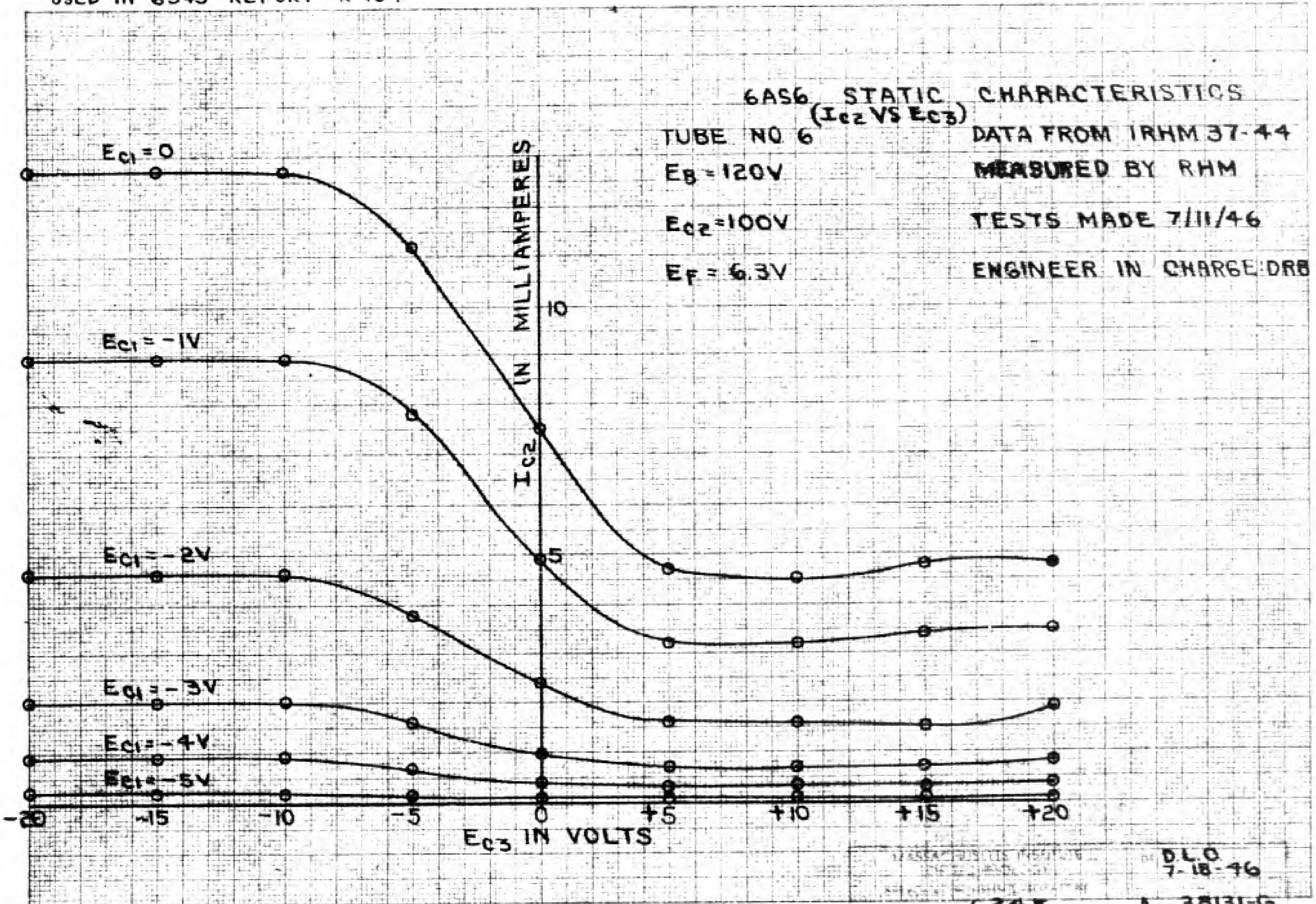
D.L.O.
7-18-46

6345

A-38130-G

-38131-G

USED IN 6345 REPORT R-104



D.L.O.
7-18-46

6345

A-38131-G

A-38132-G

USED IN 6345 REPORT R-104

TUBE NO. 6

E_B = 120V

E_{C2} = 100V

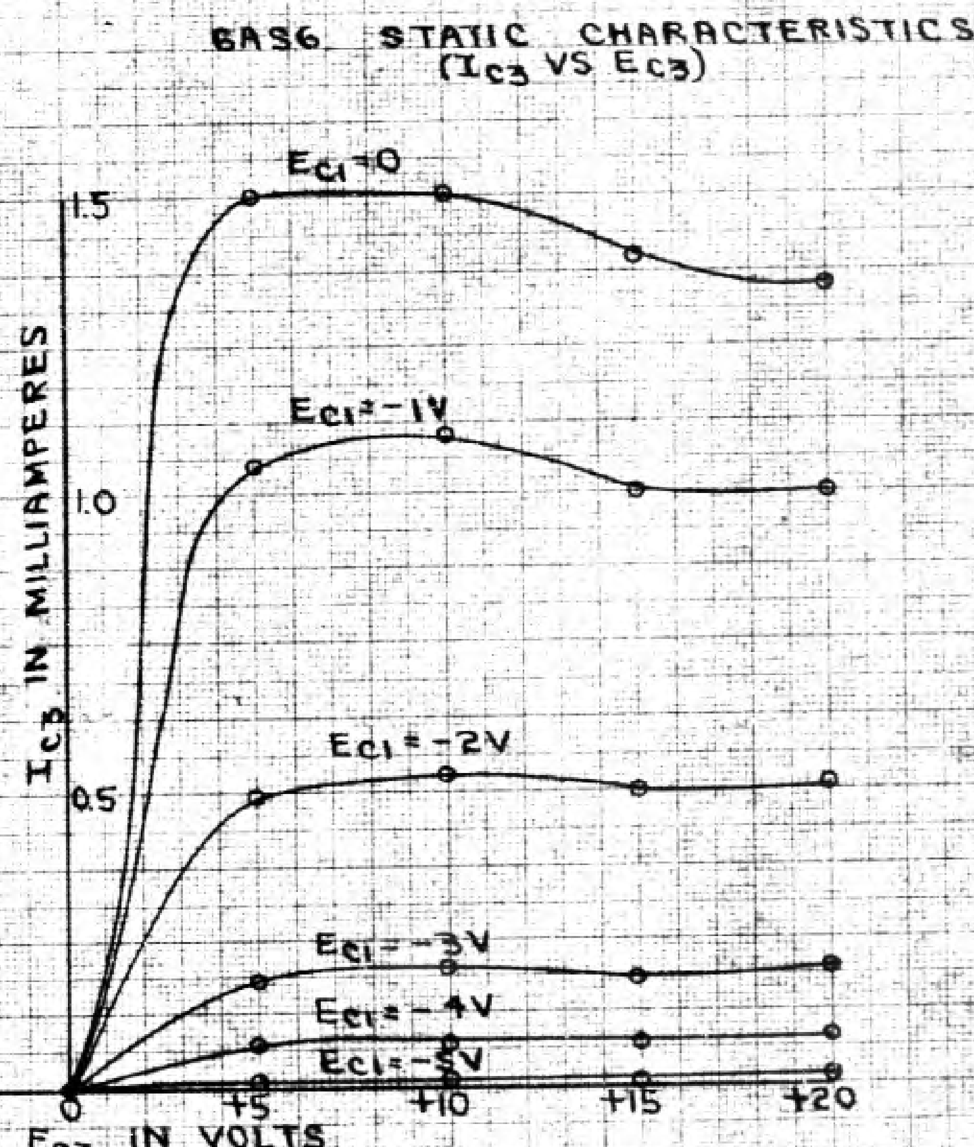
E_f = 6.3V

DATA FROM 1RHM 37-44

MEASURED BY RHM

TESTS MADE 7/11/46

ENGINEER IN CHARGE: DRB



MASSACHUSETTS INSTITUTE OF TECHNOLOGY

D.L.O.
7-18-46

6345

A-38132-G

ENGINEERING NOTE NO. 60

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO:	6345 Engineers	6345
FROM:	David R. Brown and Norman H. Taylor	Page 1 of 4
SUBJECT:	6AS6 Operation	Drawings: (See list of)
DATE:	August 5, 1947	

The Western Electric 6AS6 pentode, although it has less current-handling ability than is desired, is the best gate tube available for WWI at the present time. Particular care must be exercised in designing a gate circuit. When using 0.05-microsecond pulses, a load resistance no greater than 1000 ohms can be employed if the shunt capacitance is to be charged in a time comparable with the pulse width. Also, because of the small current available from the tube, a load resistance no less than about 1000 ohms can be used if a pulse large enough to operate the next tube is to be obtained. Advantage must be taken of the favorable duty cycle in order to get a pulse of sufficient amplitude across the 1000-ohm resistor. In some cases, the 6AS6 control grid must be driven positive.

6AS6 Characteristics

The control-grid and suppressor-grid transfer characteristics for the 6AS6 have been obtained using pulse techniques. All the curves were obtained by pulsing the control grid with a one-microsecond pulse at a 1000-cycle pulse-repetition frequency. The transfer characteristics were then taken by varying the control-grid bias or the suppressor-grid bias. The plate current was measured by the voltage drop across a 1000-ohm resistor and the screen-grid current was measured by the voltage drop across a 100-ohm resistor. Drawings A-38238-G to A-38249-G inclusive show the characteristics obtained. Plate and screen-grid current versus control-grid voltage and suppressor-grid voltage are plotted for screen and plate-supply voltages of 150, 200, and 250 volts. The curves show the high and low of the six tubes tested.

On the basis of these curves, a number of specific circuits in the register panel and the multiplier panel were redesigned.

Check-Register Read-In Gate

A gate tube must drive the flip-flop trigger tube. A minimum pulse amplitude of 10 volts is required, a nominal 22 volts. The gate tube should be selected to produce a minimum pulse amplitude of 16 volts, a nominal 22 volts. The recommended gate circuit is shown in Drawing SA-39310. The control grid and the suppressor grid are to be driven to cathode potential.

Check-Register Read-Out Gate

A gate tube, held open by a flip-flop, must drive a line driver. The coupling from flip-flop to gate tube shown in Drawing SA-39304 may permit the bias on the suppressor grid to rise to -13 volts at the end of a restorer period. Then, the screen-grid voltage can be made no higher than 150 volts. In order to get a signal large enough to operate the line driver, the control grid of the 6AS6 must be driven to zero or slightly positive. The bias on the line driver has been reduced from -20 volts to -15 volts. The cutoff for the line driver is believed to be about -13 volts.

Program-Register Read-In Gate

A gate tube must set a flip-flop. This presents no great problem, since only 4 volts, minimum, are required to switch the flip-flop. The circuit of Drawing SA-39309 is recommended.

Gate Tube to Delay Line; Suppressor at Zero

In the multiplier, a gate tube must feed a negative pulse to a flip-flop control grid through a delay line. Design center should be such that an average tube will give a 15-volt pulse at the end of the delay line. Assuming 25% attenuation in the line, the plate swing of the 6AS6 should be 20 volts. As the suppressor grid is controlled from a flip-flop, it is not possible to drive the suppressor positive; and, the control to obtain 20 milliamperes plate current it is necessary to drive the control grid positive. The circuit shown in Drawing No. SA-39306 is one possibility; that shown in Drawing No. SA-39305 with shunt feed on the B+ to allow the delay line to be at ground potential is another.

Gate Tube Feeding Delay Line; Suppressor Positive

In several applications of the gate circuit in the multiplier the suppressor can be held at a positive potential of 5-10 volts. This increases the available plate current appreciably and does not require the control grid to be driven positive to obtain the required 20 volt plate swing. Drawing SA-39311 indicates the circuit for this use.

Gate Tube With Suppressor at Zero Feeding Delay Line and Also Second

Gate With Suppressor Positive

Circuit Drawing No. SA-39308 shows the read-in gate from A-Register to Accumulator.

A 20-volt pulse is needed at the input to the delay line to insure a 15-volt output pulse at the receiving end. This 20-volt pulse must be obtained with suppressor grid of V_1 at zero potential and, therefore, the control grid of V_1 must be driven positive. The second gate tube, V_2, does have its suppressor grid held positive, however, so this tube gives satisfactory output with the control grid driven to zero. As shown, V_2 is biased to -20 volts to allow for the 20-volt pulse from V_1. The present triangular pulse, however, does not allow this treatment as the used portion of the pulse is too narrow to allow plate current to build up. It will be necessary to attenuate this signal or allow the control grid of V_2 to draw current and self-bias itself. This application is pending final design.

Gate Tube to Give Both Positive and Negative Pulses into Delay Lines

One circuit in the multiplier calls for a negative pulse at the end of one delay line, and a positive pulse at the end of a second delay line.

The proposed circuit shown on Drawing SA-39307 allows both control grid and suppressor grid to go positive and thus develops 20 volts across a 500 ohm load. The transformer inverts the signal thus providing both polarities simultaneously.

David R. Brown
David R. Brown

Norman H. Taylor
Norman H. Taylor

DRB/NHT/rp

List and Order of Drawings

A-38238-G

A-38239-G

A-38240-G

A-38241-G

A-38242-G

A-38243-G

A-38244-G

A-38245-G

A-38246-G

A-38247-G

A-38248-G

A-38249-G

SA-39310

SA-39304

SA-39309

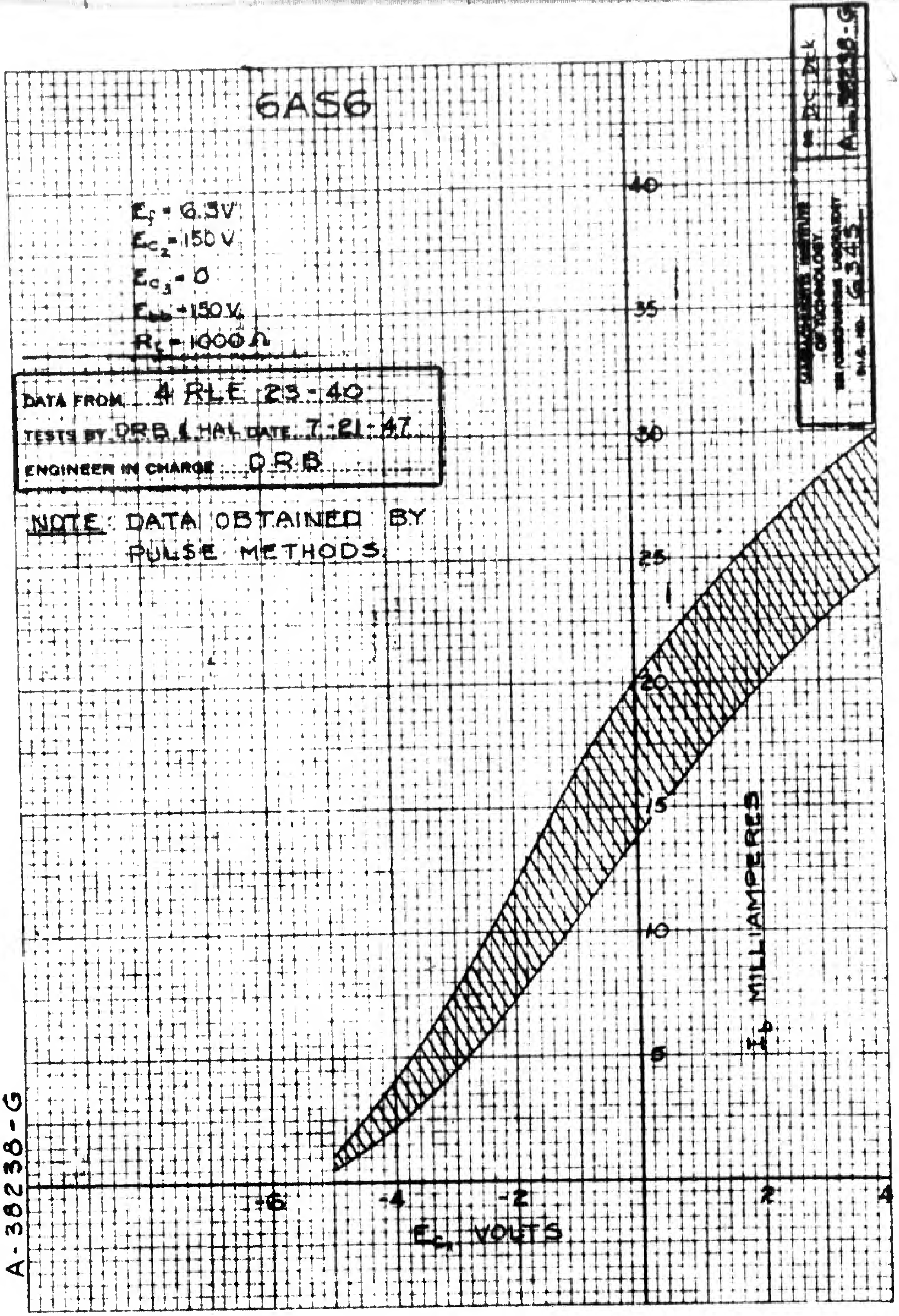
SA-39306

SA-39305

SA-39311

SA-39308

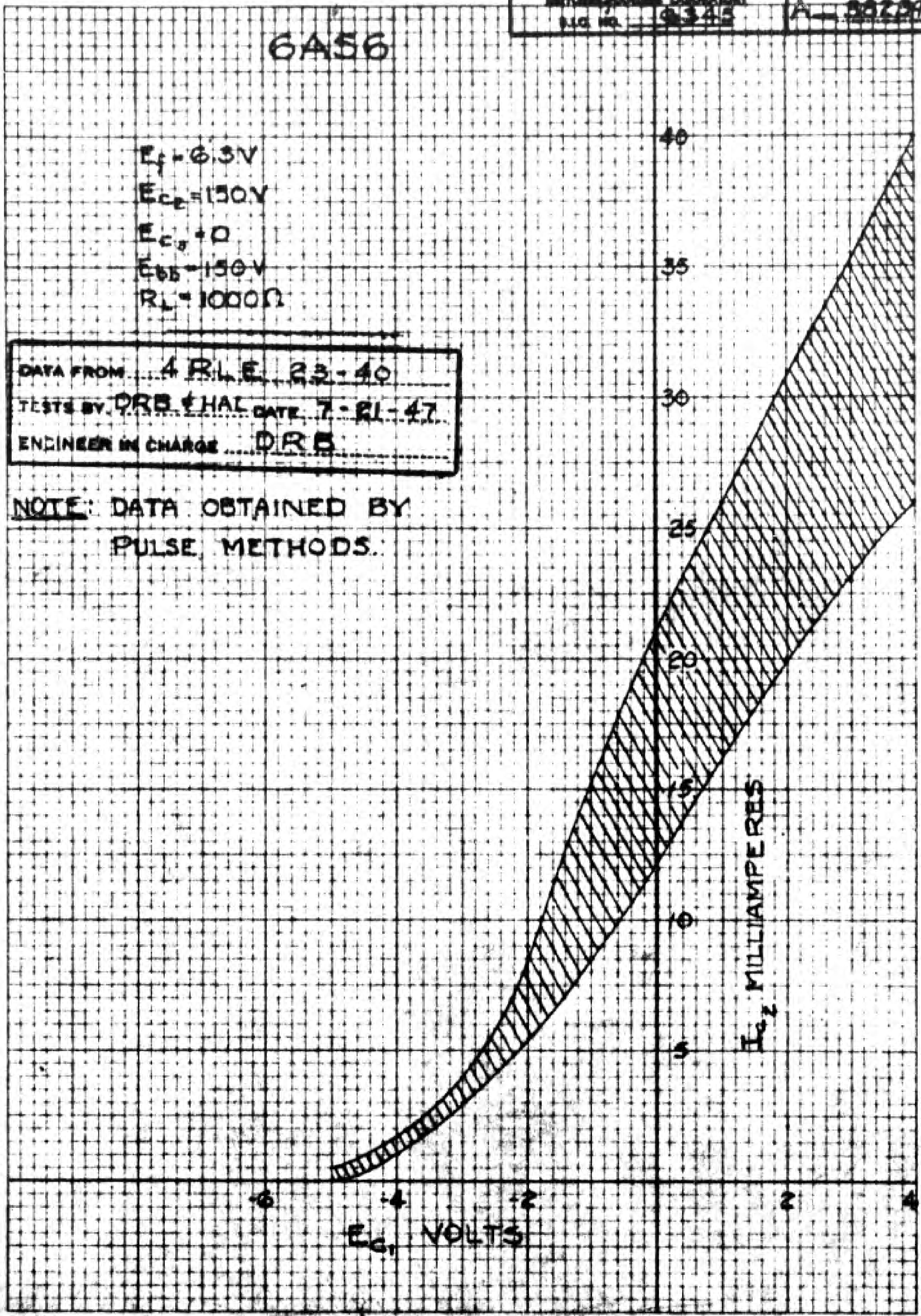
SA-39307



USED IN 6345 ENG. NOTE E-50

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY
D.I.C. NO. 6345

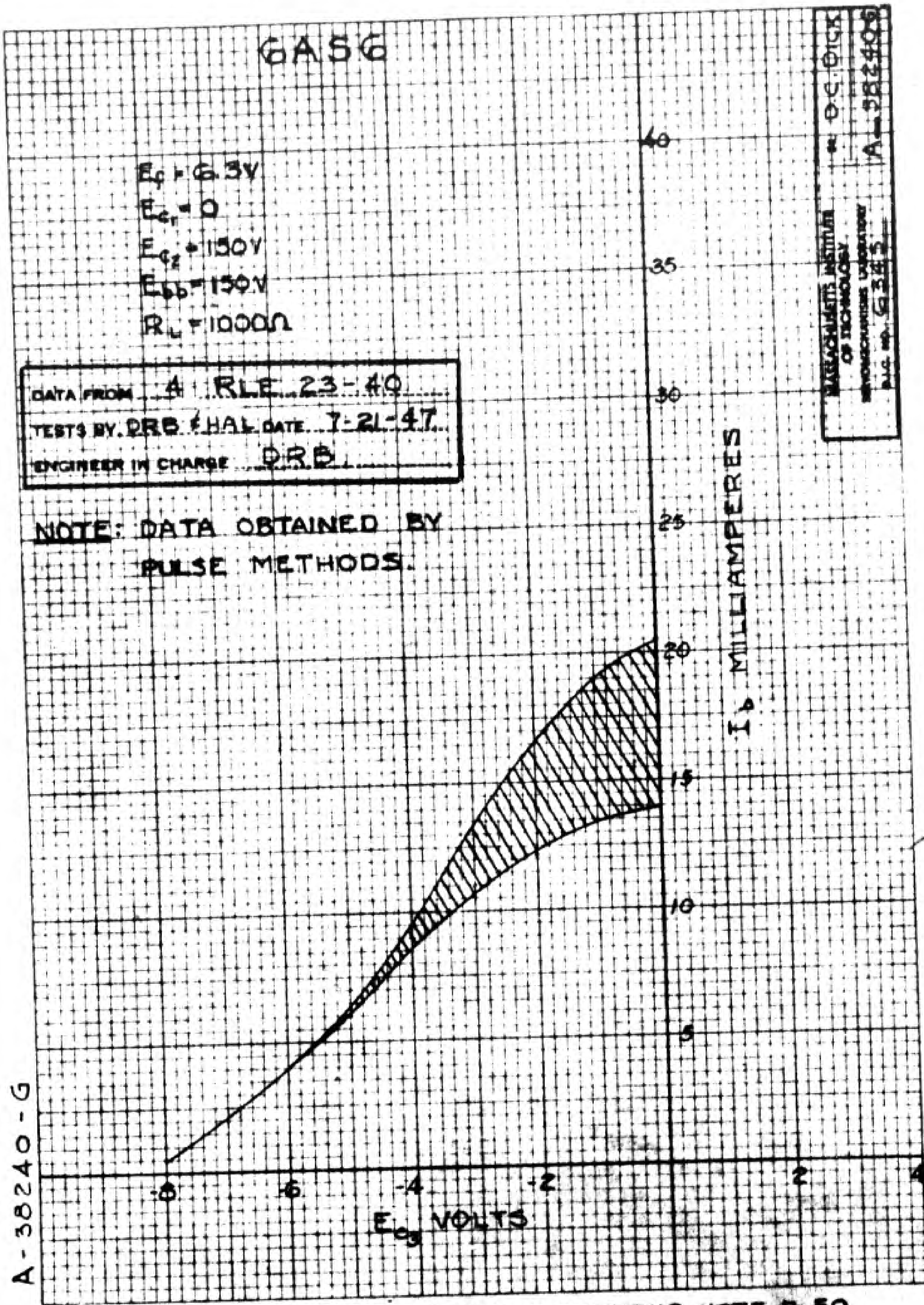
DR. D.C. DICK
A-38239-G



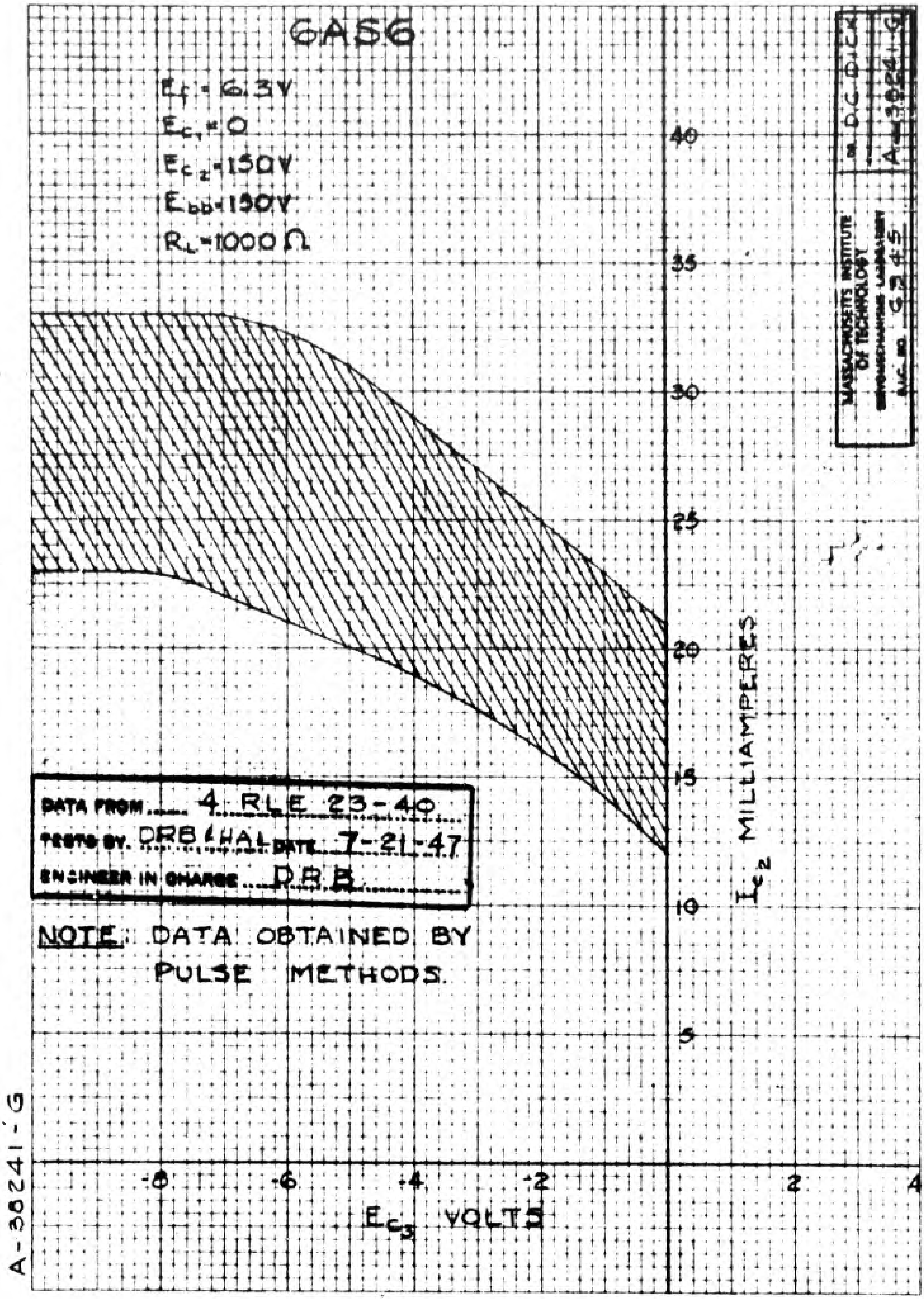
A-38239-G

NO 340-10 DIETZGEN GRAPH PAPER 10 X 10 PER INCH

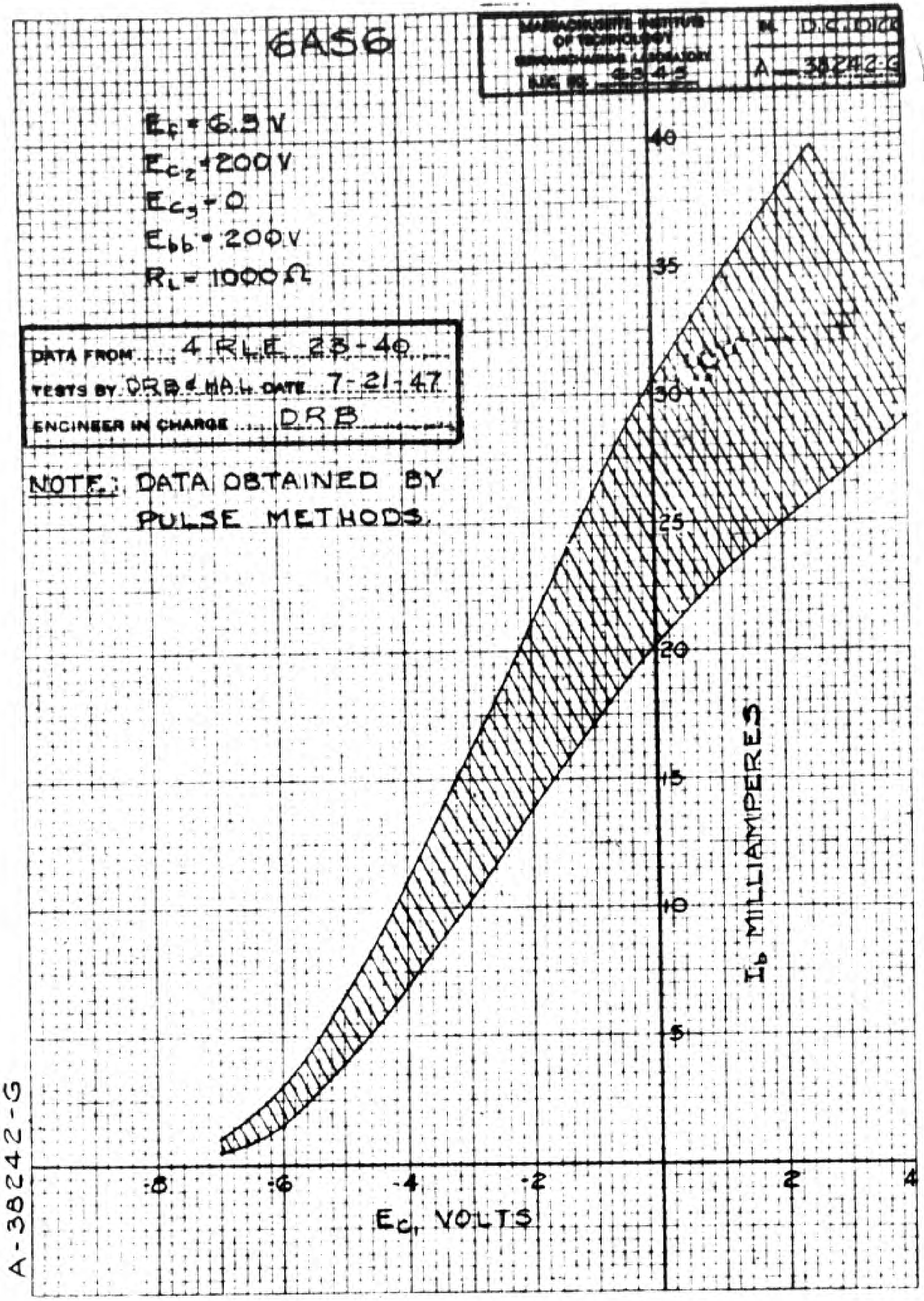
USED IN 6345 ENG. NOTE E-50



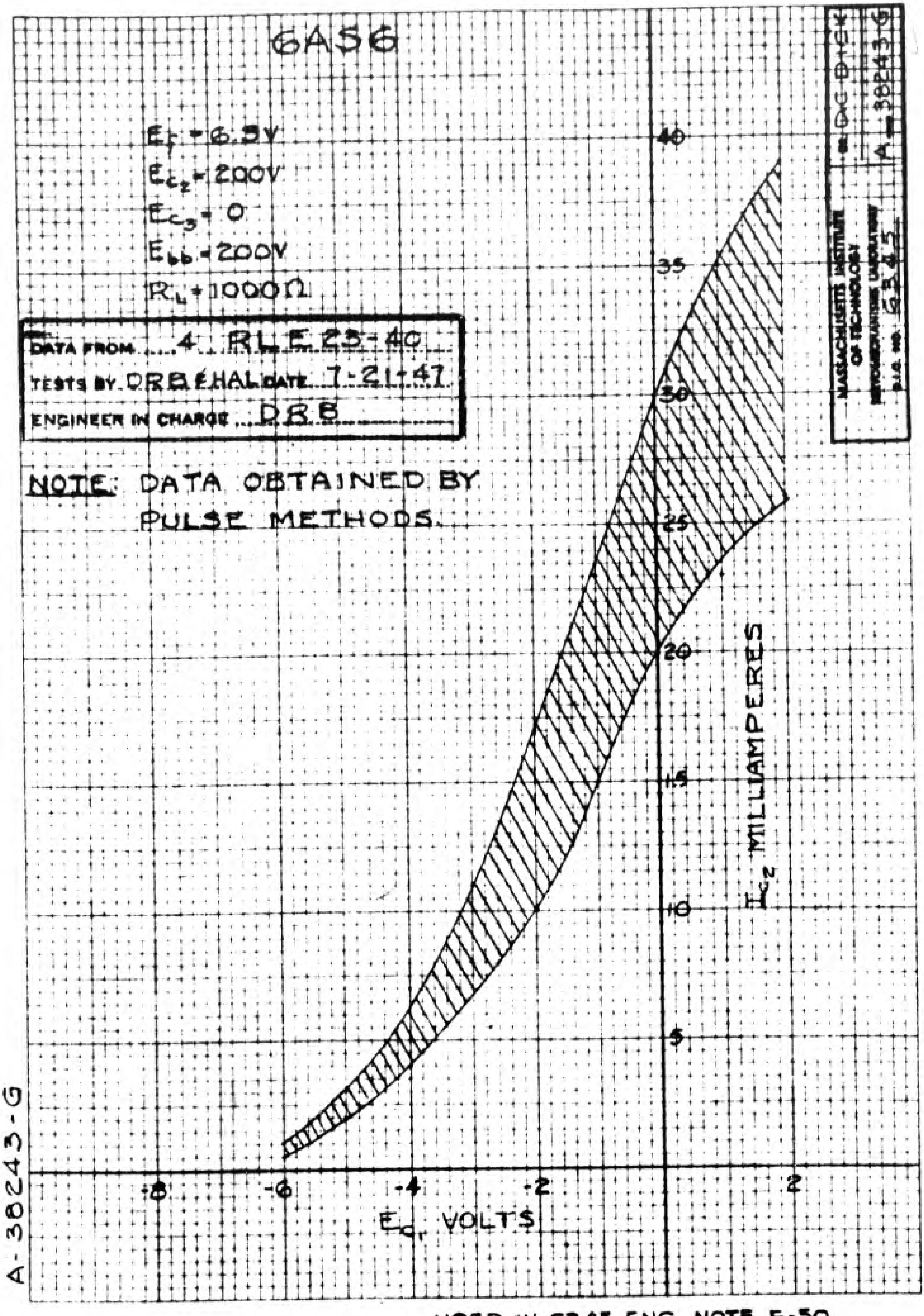
USED IN 6345 ENG. NOTE E-50



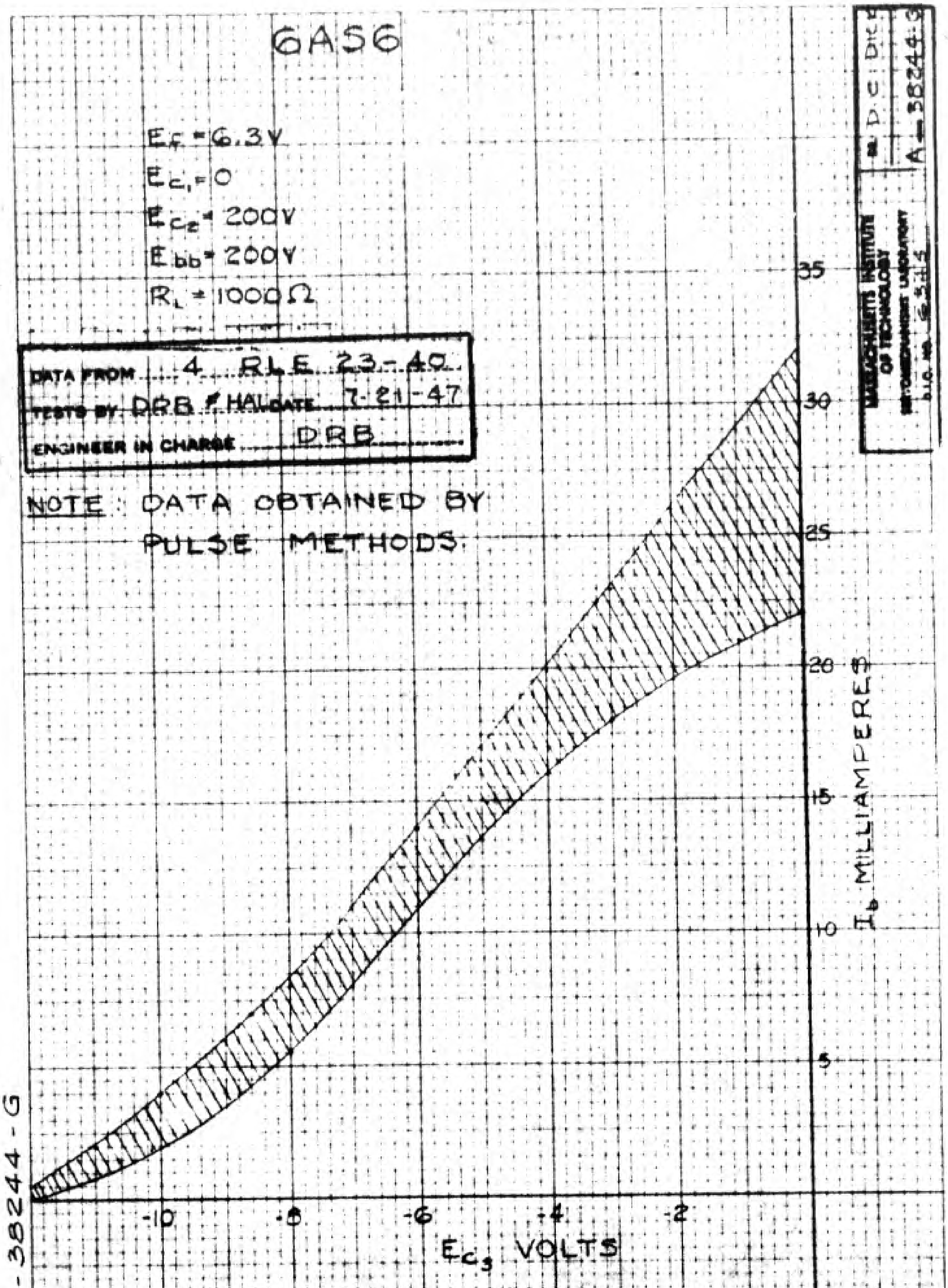
USED IN 6345 ENG. NOTE E-50



USED IN G345 ENG. NOTE E-50



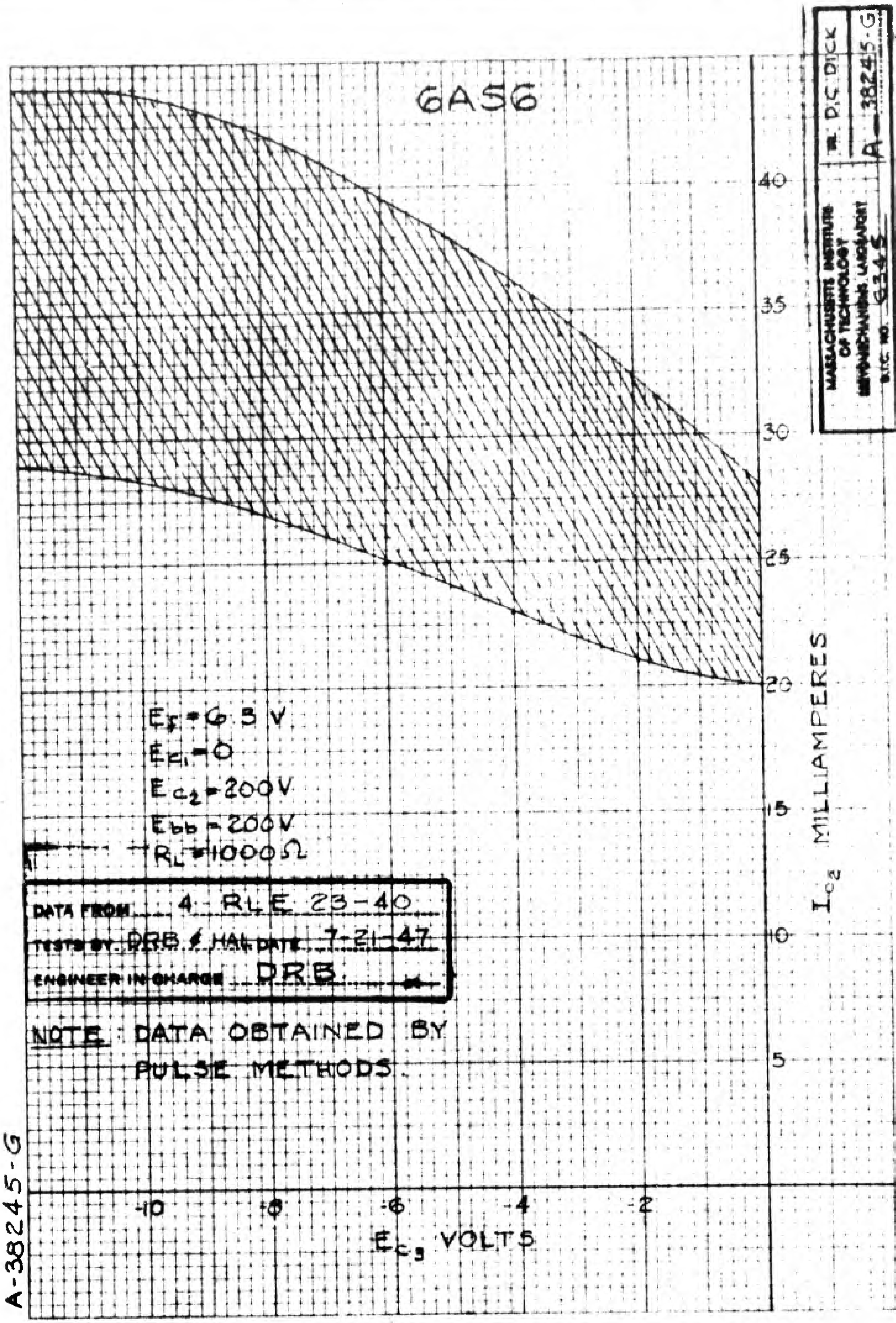
USED IN 6345 ENG. NOTE E-50



USED IN 6345 ENG. NOTE E-50

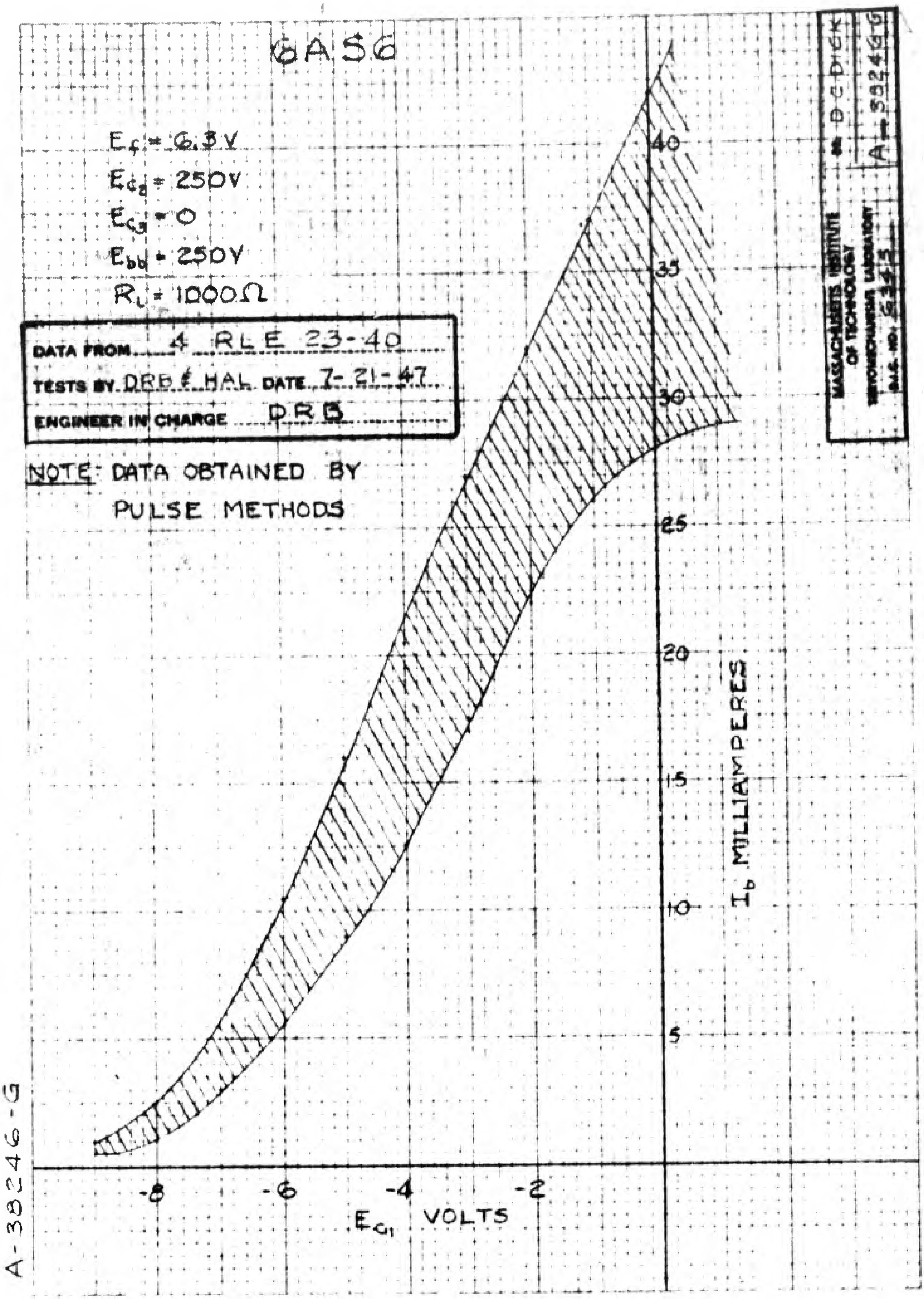
EUGENE DIETZGEN CO.

NO. 340-10 DIETZGEN GRAPH PAPER 10 X 10 PER INCH

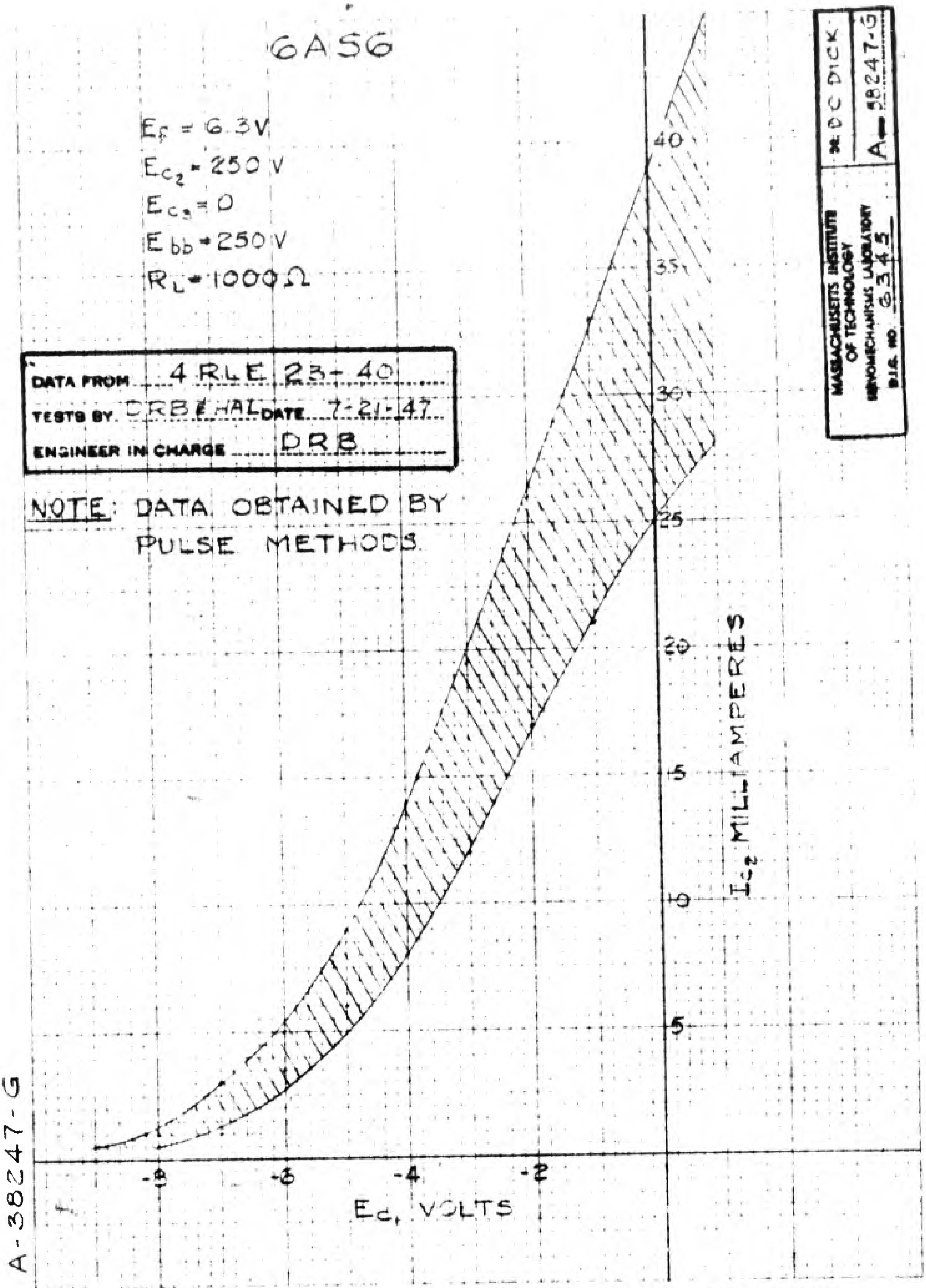


A-38245-G

USED IN G345 ENG NOTE E-50

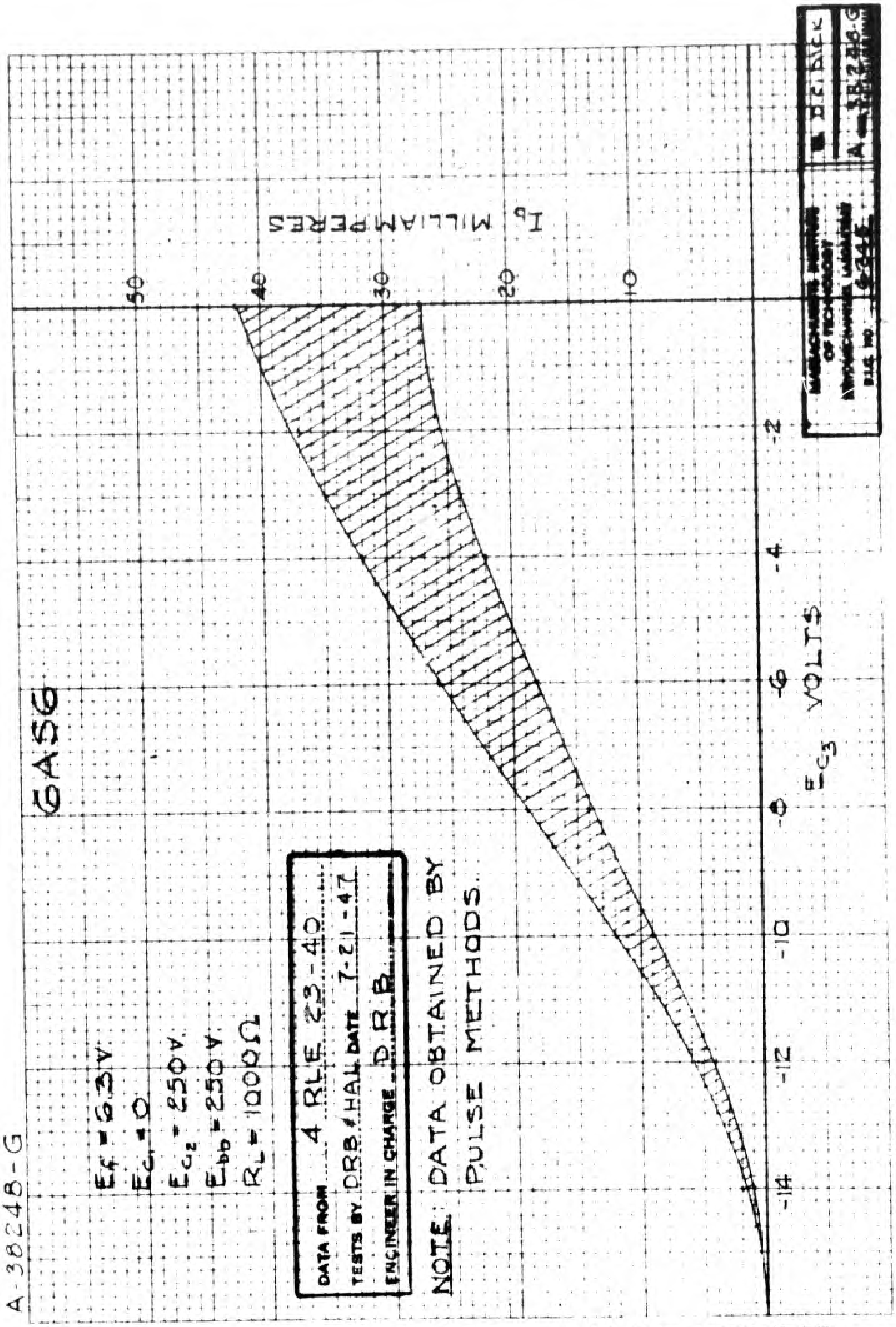


USED IN 6345 ENG. NOTE E-50



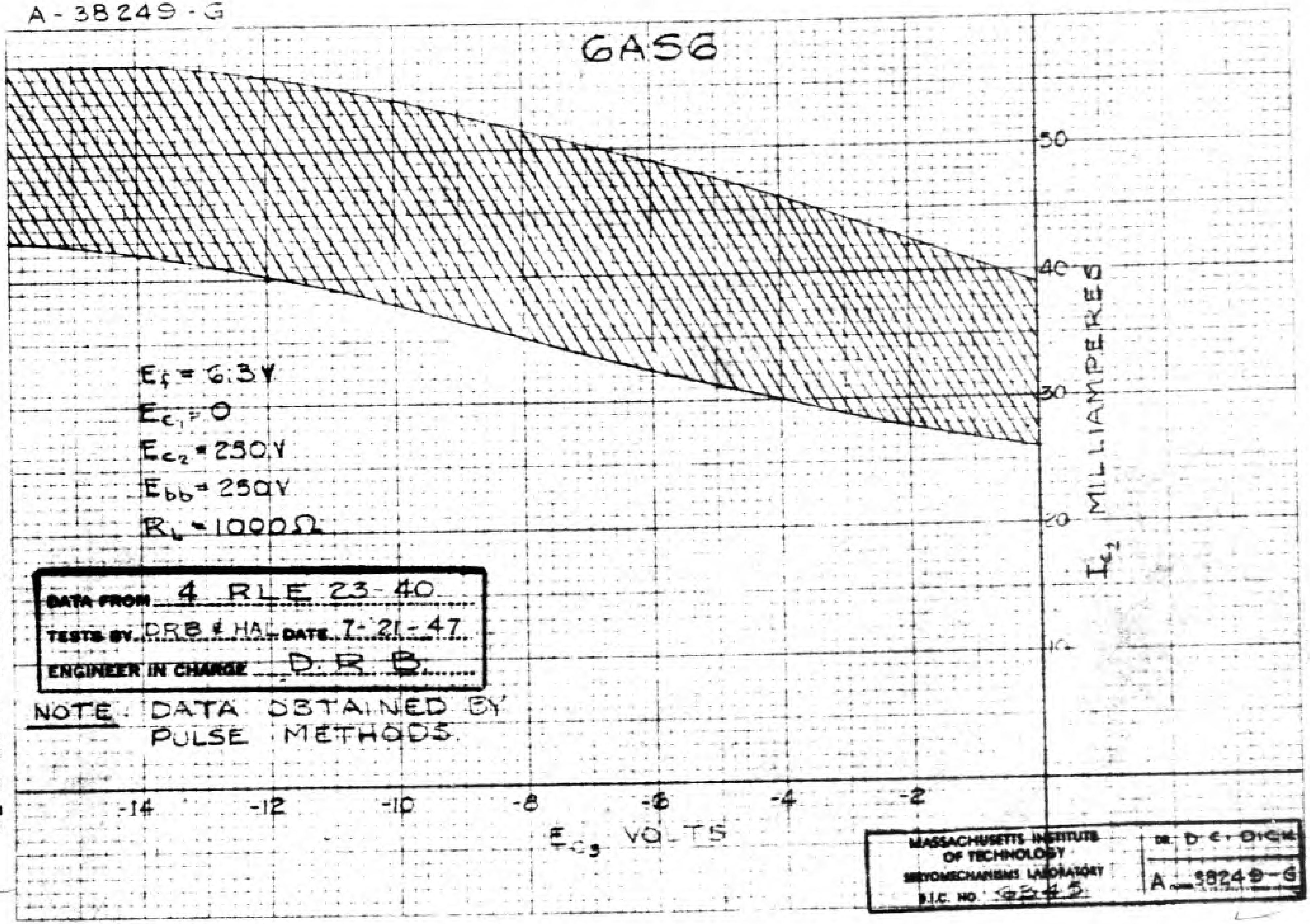
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY
DIC. NO. 6345
DC DICK
A—38247-G

USED IN 6345 ENG NOTE E-50

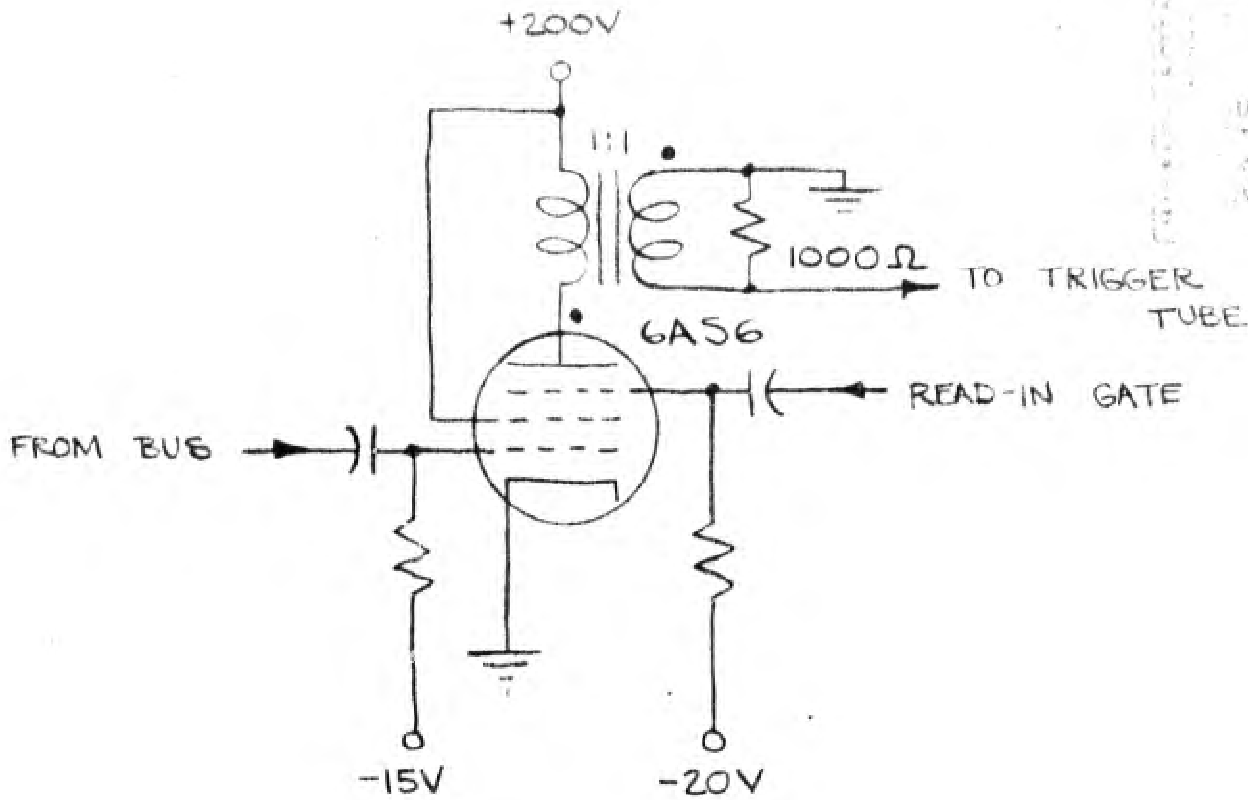


USED IN 6345 ENG. NOTE E-50

A-38249-G



USED IN 6345 ENG. NOTE E-50



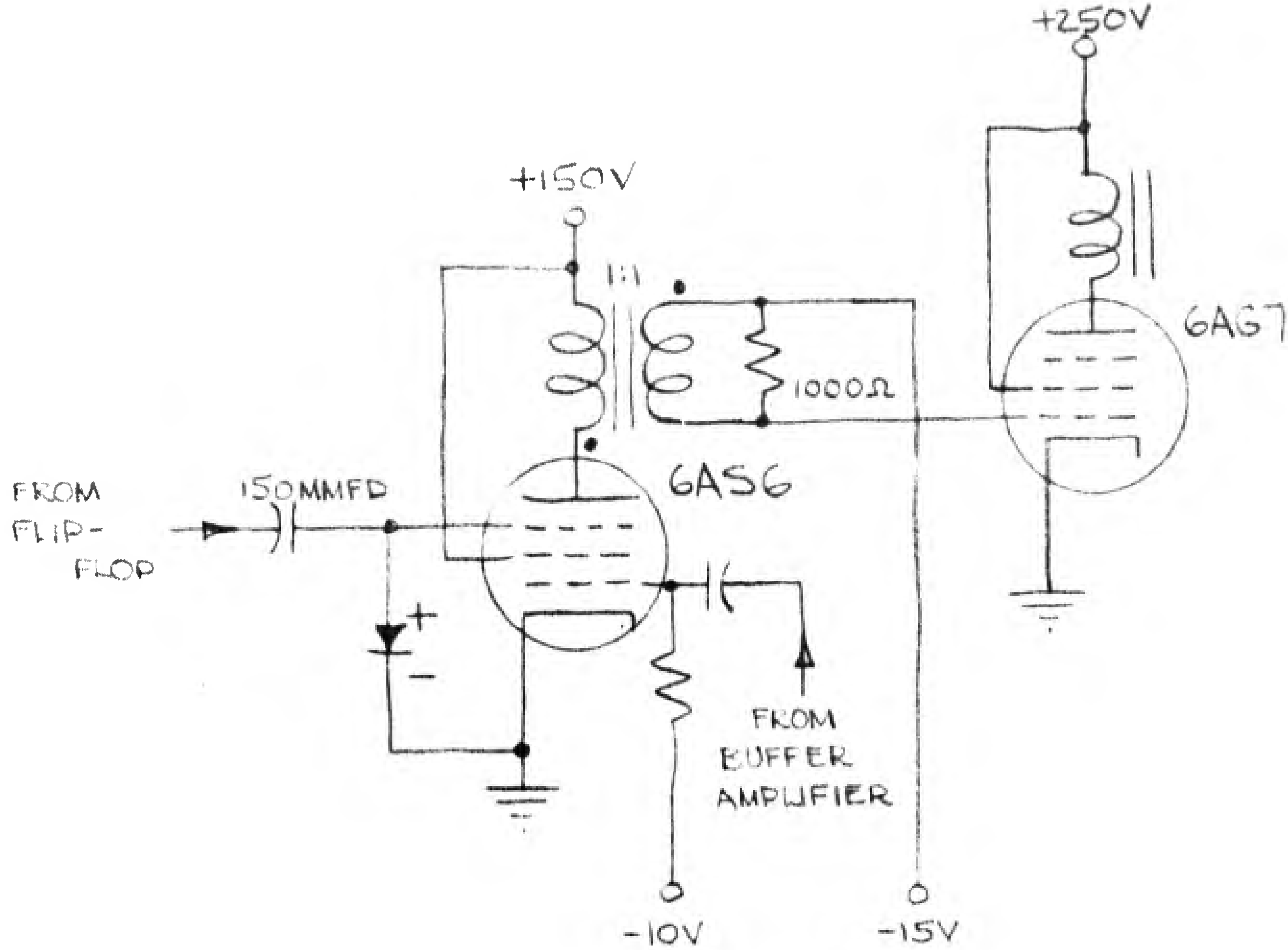
READ-IN GATE CIRCUIT TO DRIVE A TRIGGER-TUBE

JULY 30, 1947 D.R.B.

SA-33710

E-50
USED IN 6345 ENG. NOTE E-45

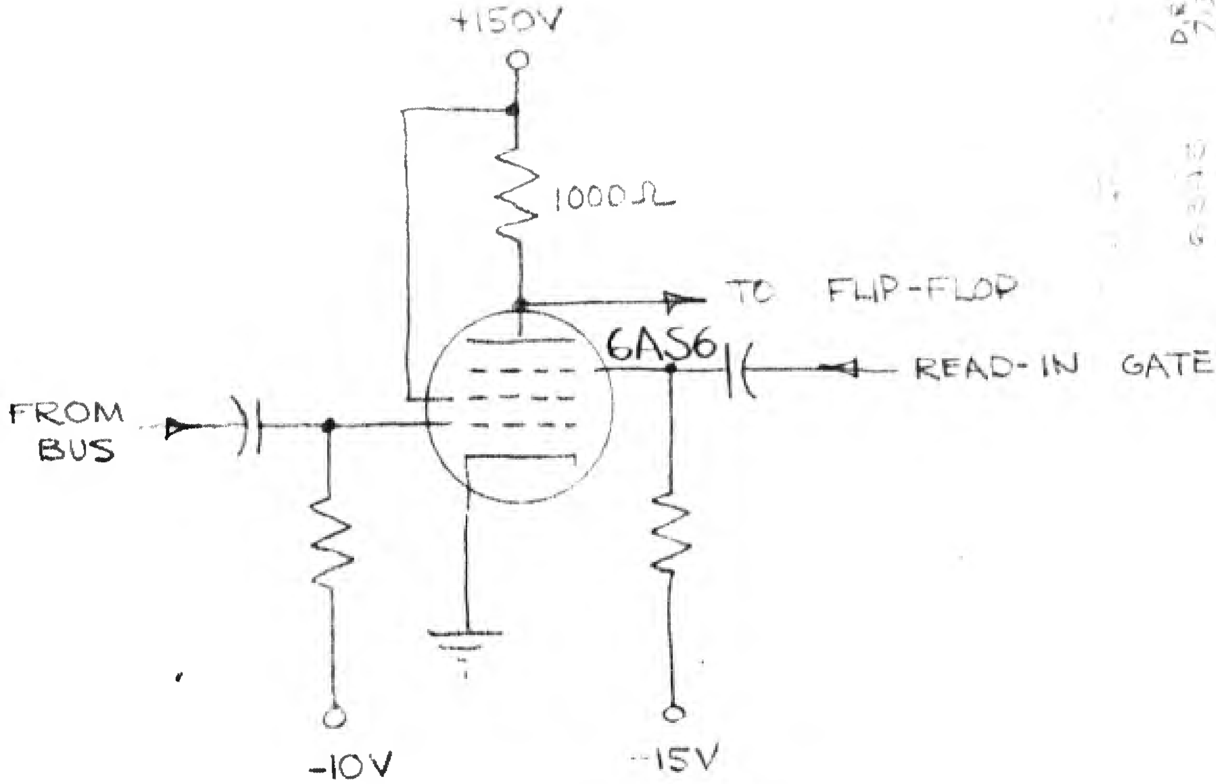
D.R.B.
7/30/47



READ-OUT GATE CIRCUIT

JULY 30, 1947 D.R.B.

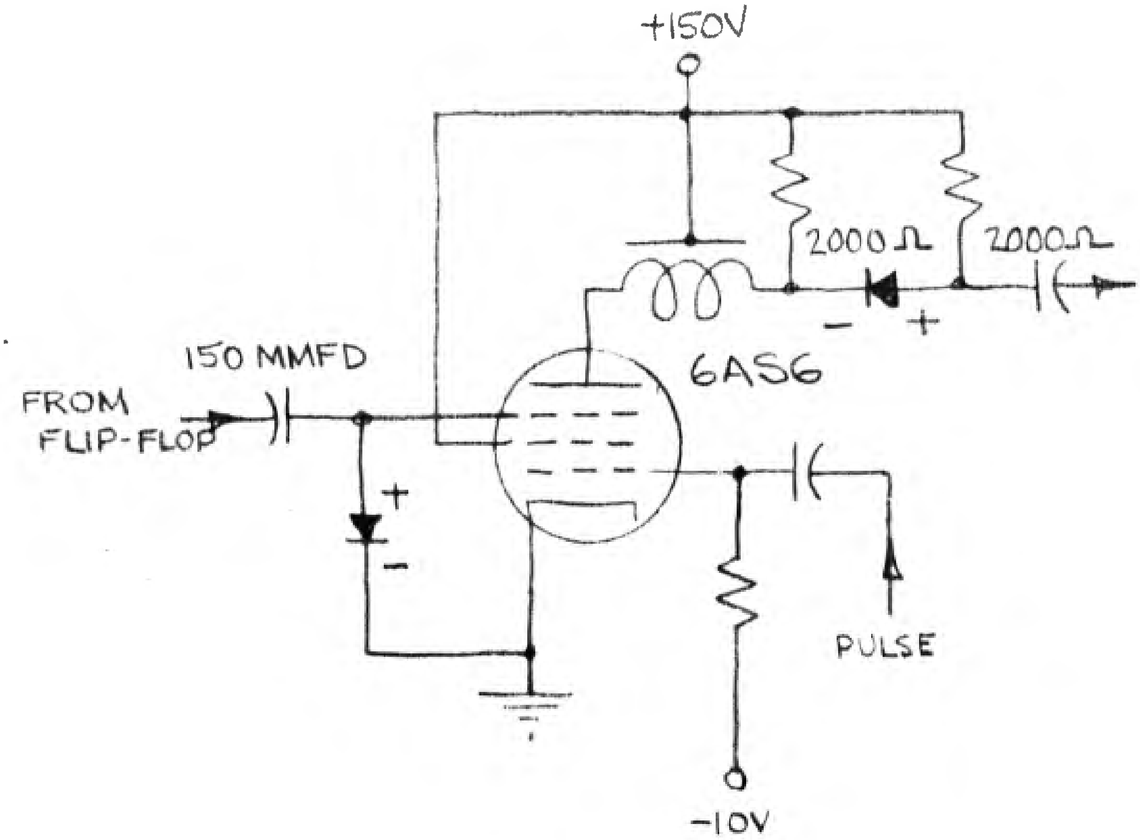
USED IN 6345 ENG. NOTE E-45 & E50



READ-IN GATE CIRCUIT
TO SET A FLIP-FLOP

JULY 30, 1947 D.R.B.

USED IN 6345 ENG. NOTE E-45 & E-5

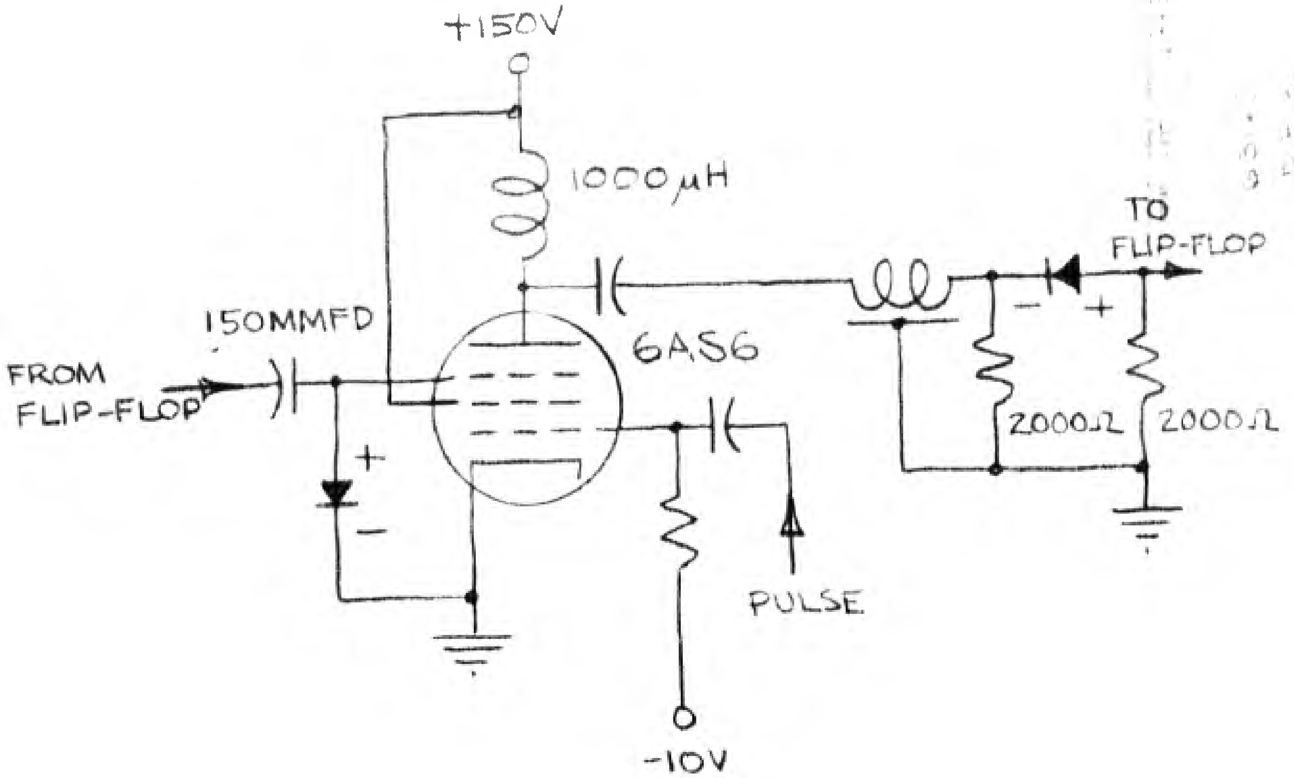


GATE CIRCUIT WITH DELAY-
LINE LOAD TO PRODUCE
NEGATIVE PULSE —
SERIES FEED

JULY 30, 1947

D.R.B.

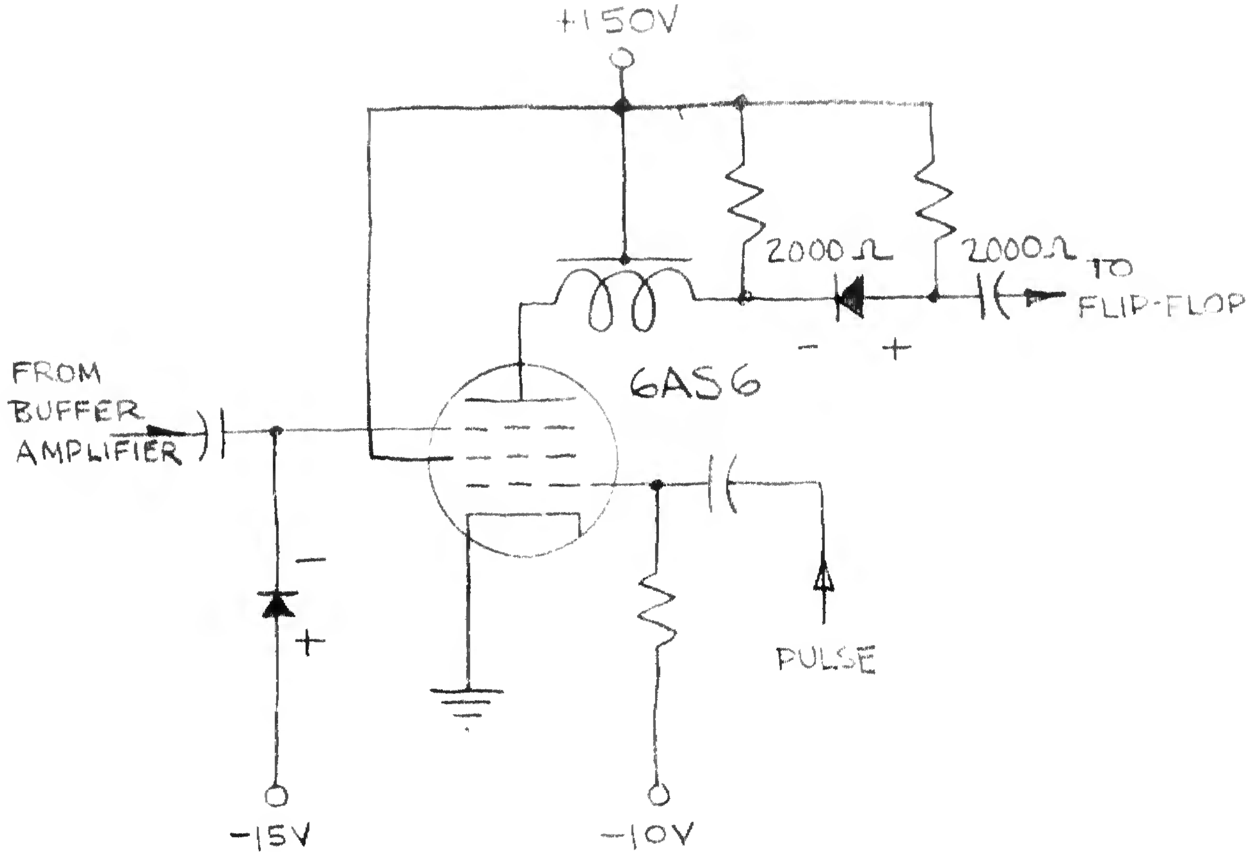
USED IN. 6345 ENG. NOTE E-45 & E-50



GATE CIRCUIT WITH DELAY-LINE LOAD TO PRODUCE NEGATIVE PULSE — SHUNT FEED

JULY 30, 1947 D.R.B.

USED IN 6345 ENG. NOTE E-45 & E-50

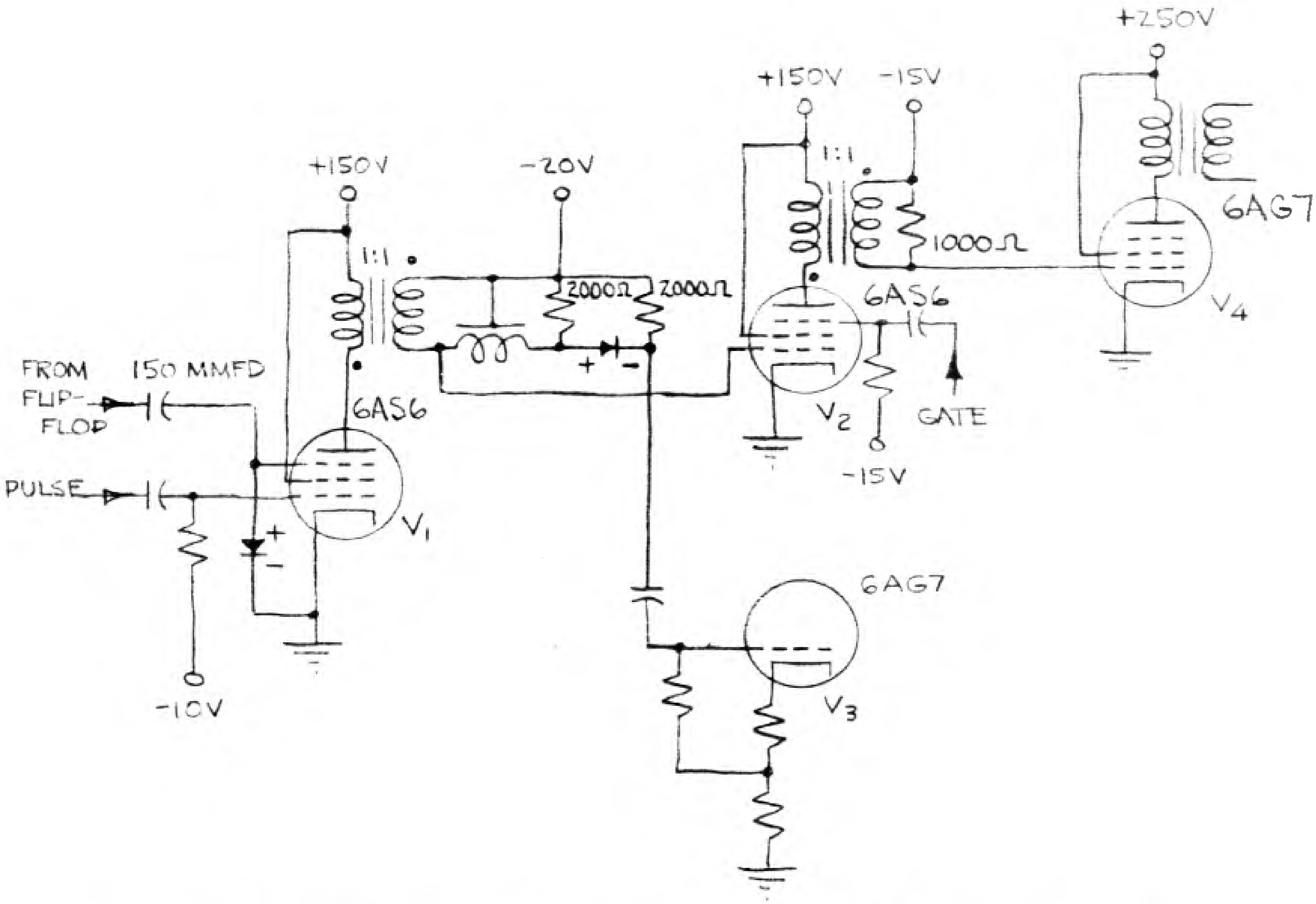


GATE CIRCUIT WITH DELAY-LINE LOAD TO PRODUCE NEGATIVE PULSE — SUPPRESSOR POSITIVE

D.R.B.

JULY 30, 1947

USED IN 6345 ENG NOTE E-45 & E50

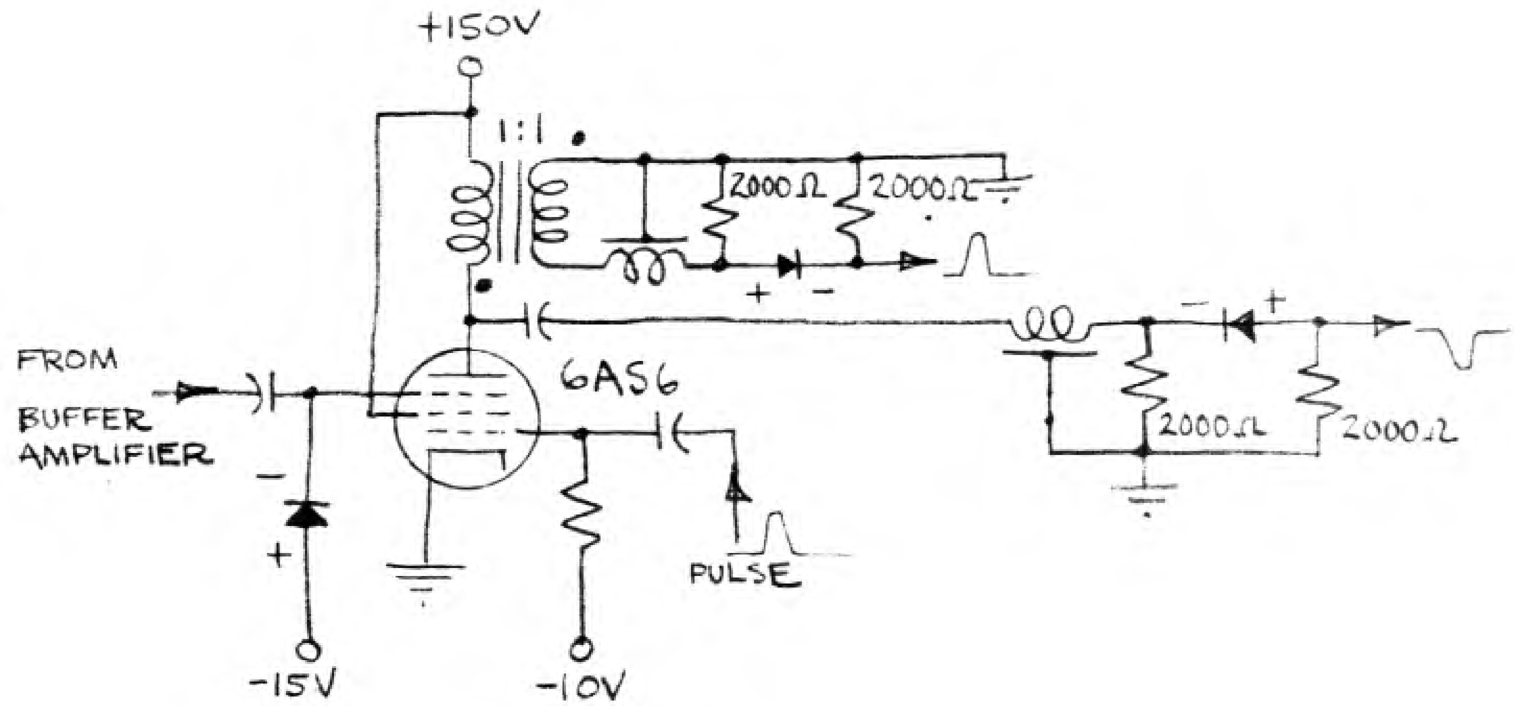


GATE CIRCUIT DRIVING A GATE TUBE
AND A DELAY LINE

JULY 30, 1947

D.R.B.

E-50
USED IN 6345 ENG NOTE E-45



GATE CIRCUIT PRODUCING DELAYED
POSITIVE AND NEGATIVE PULSES

JULY 30, 1947

D.R.B.

USED IN 6345 ENG. NOTE E-45 & E-50

ENGINEERING NOTES NO. E-61

Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO: 6345 Engineers — 6345

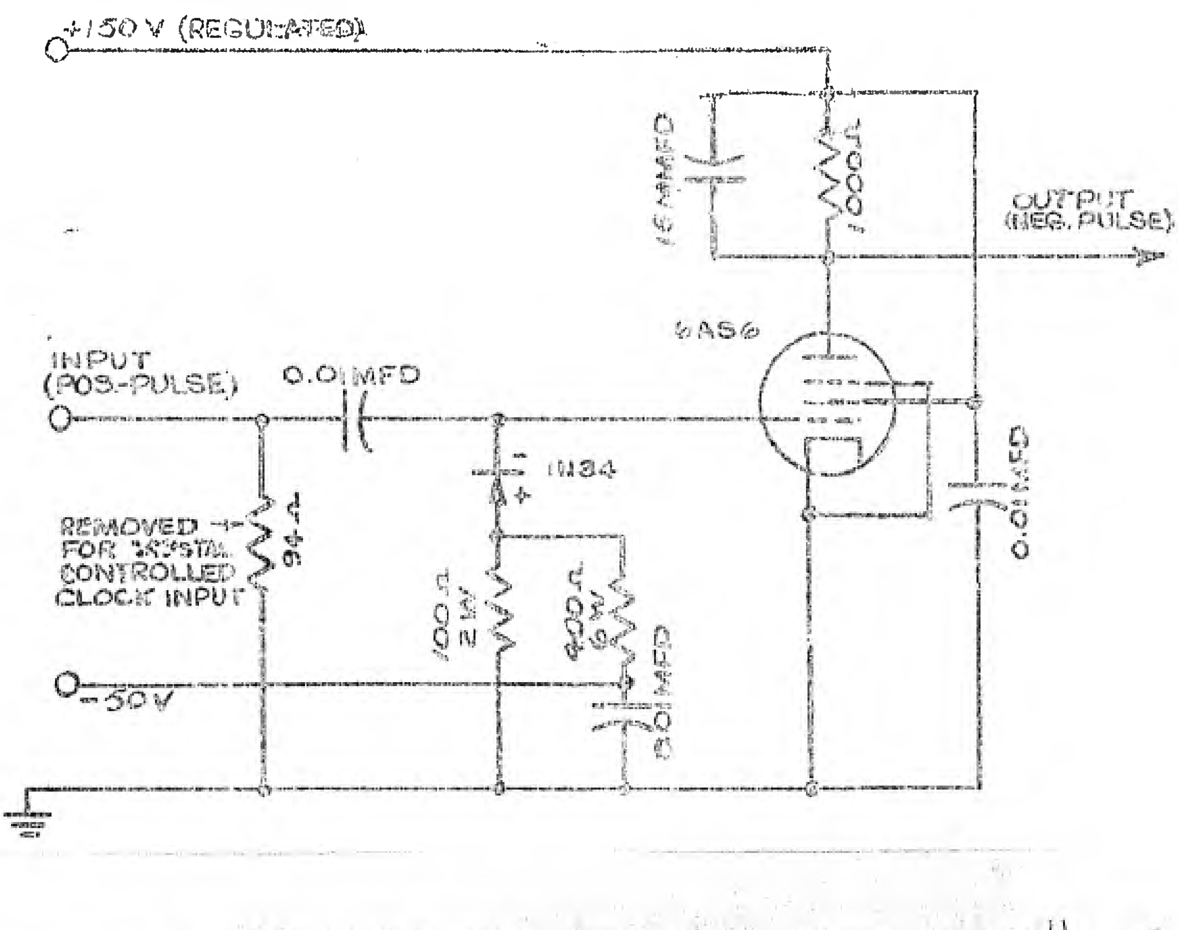
FROM: Eugene W. Sard — Page 1 of 4

SUBJECT: Output Amplitude of Gate Tubes Versus Input Pulse Width

DATE: September 11, 1947

INTRODUCTION: It is to be expected that as input pulse widths are made narrower, the output amplitude of gate tubes will decrease when the time constant of the plate circuit is no longer very small compared with the input pulse width. For a gate tube with resistance plate load, the plate circuit time constant for the leading edge of the output pulse is the product of the parallel combination of the plate load resistor and the r_p of the tube, and the capacitance from plate to ground. This capacitance is composed of the output capacitance of the gate tube, the stray and wiring capacitance, and the input capacitance of the following stage. The input capacitance of approximately 7 MMFD of the Model 5 Synchroscope is also added to the capacitance from plate to ground when the plate waveform is being observed.

EXPERIMENTAL WORK: The circuit shown below was more or less arbitrarily selected to show the desired behavior.



The crystal clamping circuit is to insure that the base-line of the input pulses is clamped to the tap on the bias voltage divider for all repetition rates (See E-59). The low resistance bias voltage divider is to minimize the building up of grid leak bias when the control grid is driven positive. The gate tube suppressor is tied to the cathode. The 15 MMFD across the plate resistor represents the input capacitance of a following stage plus additional stray and wiring capacitance.

Three inputs were used in the course of the work. The first was a gas-tube pulse generator putting out rectangular pulses at 2000 cps. (Dwg. C-30367-1). The second was a crystal-controlled clock putting out trapezoidal pulses at 1 MC (See E-18). The third was a variable-frequency clock putting out rounded half-sinusoidx at about 1.1 MC (See E-48). Both the gas-tube pulse generator and the crystal-controlled clock were putting out pulses of sufficient duration to fully charge the plate circuit capacitance as could be seen by the shape of the gate-tube output pulse. The width of the rounded pulse from the other clock was kept constant at different amplitudes by simultaneously varying the clock amplitude control and the setting of an external attenuator box. Pulse width of this clock was varied by changing the L and C of an RLC peaker in the clock.

The following data were taken using the Model 5 Synchroscope:

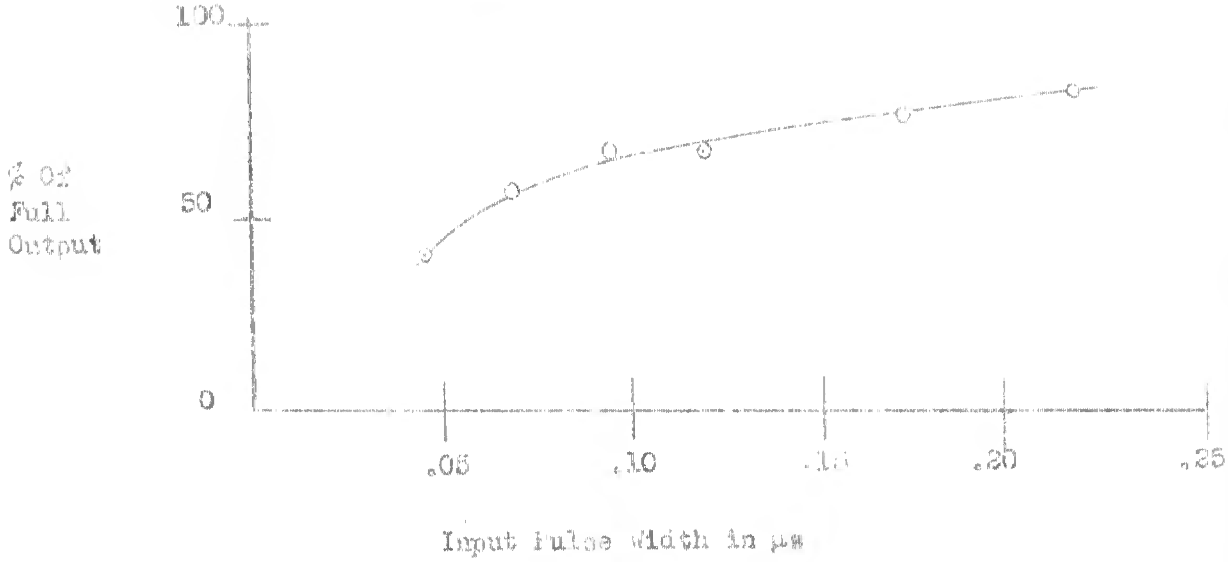
INPUT AMPLITUDE (Volts)	TYPE INPUT	(Measured at base) INPUT WIDTH (μs)	OUTPUT AMPLITUDE (Volts)	% OF FULL OUTPUT (Based on Gas-Tube Pulse Generator)
9	Gas Tube Pulse Gen. Rect. Pulse, 2000 cps	Sufficient	19	100
	XTal-Controlled Clock, 1 MC Trapezoidal Pulse	Sufficient	19	100
	Variable-Frequency Clock Round Pulse 1.1 MC	0.046	7	37
		0.069	10	53
		0.092	14	74
		0.115	13	68
		0.17	14	74
		0.22	17	89

INPUT AMPLITUDE (Volts)	TYPE INPUT	INPUT WIDTH (μs) (Measured at base)	OUTPUT AMPLITUDE (Volts)	% OF FULL OUTPUT (Based on Gas-Tube Pulse Generator)
12	Gas-Tube Pulse Gen. Rect. Pulse, 2000 cps	Sufficient	30	100
	XTal-Controlled Clock, 1 MC Trapezoidal Pulse	Sufficient	27	90
	Variable-Frequency Clock 1.1 MC Round Pulse	0.046	11	37
		0.069	17	57
		0.092	19	63
		0.115	20	67
		0.17	23	77
		0.22	22	73
15	Gas-Tube Pulse Gen. Rect. Pulse, 2000 cps	Sufficient	37	100
	XTal-Controlled Clock, 1 MC Trapezoidal Pulse	No pulse available	-	-
	Variable-Frequency Clock 1.1 MC Round Pulse	0.046	17	46
		0.069	21	57
		0.092	24	65
		0.115	24	65
		0.17	28	76
		0.22	31	84

Since the percentages of full output for different input amplitudes were grouped fairly close together for a given input pulse width, it was thought justifiable to average the percentages for a given pulse width. These averages are tabulated below.

INPUT PULSE WIDTH (μs)	% OF FULL OUTPUT
0.046	40
0.069	56
0.092	67
0.115	67
0.17	75
0.22	82

Points from this table are plotted below



It is thought that the clamping scheme and the low resistance bias voltage divider were fairly successful since the gate tube output amplitude was nearly the same for the 1 MC crystal-controlled clock as it was for the 2000 cps gas-tube pulse generator.

Eugene W. Sard
Eugene W. Sard

EWS.has

MEMORANDUM NO. M-105

SERVOMECHANISMS LABORATORY
Massachusetts Institute of Technology
Cambridge, Massachusetts

To:	J.W. Forrester, R.R. Everett, J.R. Boyd, H. Fahnestock, N.H. Taylor, W.L. Hiser (Sylvania Emporium), N. Rochester (Sylvania, Boston), R.C. Moses (Sylvania, Boston).	6345
From:	David R. Brown and Norman H. Taylor	Page 1 of 8
Subject:	Gate-Tube Development	Drawings: (See List)
Date:	September 17, 1947	
References:	A. Eugene W. Sard's Engineering Note E-61.	
	B. Project Whirlwind Engineering Note E-60, <u>6AS6 Operation</u>, D. R. Brown and N. H. Taylor.	
	C. Memorandum #80 I. D. Wilson, "Gate Tubes in WWI".	

<u>Introduction</u>

This memorandum presents the results of tests on the Sylvania SR-1030 gate tube and indicates the number of tubes which may be used in the Whirlwind I design. The development program was initiated with the goal of replacing the existing 6AS6 gate tube and the 6AG7 pentode used as a flip-flop buffer and as a trigger tube.

The 6AS6 is a Western Electric minature; it is entirely inadequate as pointed out in Memorandum No. 80 by I. D. Wilson.

The 6AG7 gives adequate performance in all applications but has a questionable history as to reliability and long life.

<u>Results</u>

There are 3 types of circuits in the WWI design where the proposed gate tube might be used. They are:

1. Gate Tubes
2. Buffer Amplifiers
3. Flip-Flop and Trigger Tubes

At the present stage of development the SR-1030 will replace the 6AS6 gate tube and give a margin of 2 to 1 in output. This performance is realized without overdrive to the positive region on the #1 or #3 grid. The tubes which give this performance are those in Sylvania

Group #4523. If it is possible, in the limited time available, to increase the available output current by 50% without sacrificing cutoff voltage, this tube would be satisfactory for all gate tube uses which we now have in WWI. The quantity of tubes used in the system as gates will be about 300.

When used in circuits as a Buffer Amplifier, flip-flop or trigger tube, the present development samples of the SR-1030 will not replace the 6AG7, since the current available and the cutoff voltage required are not comparable with 6AG7 performance. As the requirements in the above circuits are for high-current, sharp-cutoff pentodes, it now seems undesirable to attempt to use a gate tube in these applications. It would be better to initiate a program of a "ruggedized" 6AG7 with long-life filaments and more adequate dissipation ratings. Such a tube would need no #3 grid control nor would it be limited in size.

It is proposed therefore to limit the use of the SR-1030 gate tube to gate applications only, and to start work on another tube to replace the 6AG7. The quantity of 6AG7's used at present is approximately 1100.

Application of a New Tube

The application of new tubes can best be discussed in terms of the circuits for Whirlwind I which have been designed. These are the circuits for the multiplier panel, register panel, and flip-flop panel. The number of tubes involved for 16 digits is as follows:

multiplier panel	896
register panel	400
flip-flop panel	592
Total	1888

The total numbers of tubes estimated for Whirlwind I is 2300. For one digit the quantity is 1/16th of the number listed above. Considering just a single digit, the tubes in each panel may be classified as follows:

Multiplier Panel:

buffer amplifiers	15
buffer amplifiers (remote cutoff)	4
flip-flop tubes	8
gate tubes	21
indicator tubes	4
trigger tubes	4
Total	56

Register Panel:

buffer amplifiers	6
flip-flop tubes	6
gate tubes	7

indicator tubes		3
trigger tubes		3
	Total	25

Flip-Flop Panel:

buffer amplifiers		4
flip-flop tubes		10
gate tubes		13
indicator tubes		5
trigger tubes		5
	Total	37

The total tubes required for these three parts of the computer may also be tabulated as follows:

buffer amplifiers		400
buffer amplifiers (remote cutoff)		64
flip-flop tubes		384
gate tubes		656
indicator tubes		192
trigger tubes		192
	Total	1,888

For the whole computer the following estimates apply:

buffer amplifiers		500
buffer amplifiers (remote cutoff)		70
flip-flop tubes		400
gate tubes		800
indicator tubes		200
trigger tubes		200
		2170
power tubes		130
	Total	2300

The first and most important application of a new tube would be to replace all of the present 6AS6 gate tubes. The total number of gate tubes in the multiplier panels, the register panels, and the flip-flop panels is 656. Preliminary quantitative measurements (see Reference A) indicate that for a 0.1 microsecond half-sine-wave pulse, the output is about 67 per cent of what would be calculated from the transfer characteristic for a 1000-ohm resistive load. This means then that for a gate circuit with a 1000-ohm plate load, 30 milliamperes of plate current are required to produce a 20-volt output pulse if 0.1-microsecond half-sine-wave pulses are used. A plate-load circuit using inductive and non-linear elements may be able to improve the input-output characteristic.

The discussion of the gate-tube requirements in Reference B does not take into account the effect noted above. Hence the circuits suggested in that reference do not produce the output amplitude required. However, since that reference was written, the possibility of removing the delay lines from the plate-load circuits of the gate tubes has been suggested. If this can be done, it is possible that a gate tube that produces a 20-volt pulse across a 1000-ohm plate load will meet all of the gate-circuit requirements. Then the zero-grid plate current required would be 30 milliamperes. As shown in Reference B, a control grid cutoff voltage of -8 volts is required so that -15 volts of fixed bias can be used, requiring, then, a 15-volt pulse to operate the circuit. Also, the suppressor-grid cutoff voltage must be about -8 volts, since the flip-flop may permit the suppressor-grid voltage to rise to about -15 volts.

The next important application for a new tube would be as a buffer amplifier, to replace the 6AG7 pentode. A large percentage of the buffer amplifiers must function as line drivers. For the line driver cutoff voltage no less than -13 volts and a zero-grid plate current of about 130 milliamperes are required. For some of the buffer amplifiers only 80-milliamperes zero-grid plate current is required. The most unfavorable duty factor, if 0.1 microsecond pulses are used, is one-twentieth.

In the third group the duty factor for a flip-flop tube may be one. The present circuit uses 6AG7 pentodes and a replacement should equal their performance. The present flip-flop has a plate-supply and screen-supply voltage of 150 volts. The screen voltage is 90 volts. The plate current at zero control-grid voltage is 30 milliamperes. The control-grid cutoff voltage is -4.5 volts. The plate dissipation is 1.5 watts, whereas the rated plate dissipation is 9.0 watts. The screen grid dissipation is 0.9 watts, whereas the rated screen-grid dissipation is 1.5 watts. About 50 per cent more plate current and no change in the control-grid cutoff voltage would be desirable. Of course, no increase in the plate current but the achievement of a more reliable tube to give the same performance as the 6AG7 would be a step in the right direction.

The trigger tube is no problem. Whatever is used for the flip-flop can certainly be used as a trigger tube.

Almost any twin triode will meet the requirements for the indicator tube: e.g., 2C51, 12AU7, 7F8, 6SN7.

<u>Tests on Samples of SR-1030</u>

Five type SR-1030 (test C-4523) were received August 19 with numbers 5, 8, 11, 12, and 15.

First, the plate and screen-grid currents as a function of control-grid voltage and suppressor-grid voltage were measured.

In order to avoid excessive heating of the tube electrodes, the measurements were made using pulse techniques. The block schematic of the arrangement for the pulse tests is shown in drawing A-30904. The trigger generator triggers the pulse generator and the TS-239/UP oscilloscope at 100-cps repetition frequency. The pulse generator is adjusted to produce a 1-microsecond flat-top pulse. By means of an attenuator the pulse amplitude is adjusted to some convenient amplitude, say 10 volts. This 10-volt positive pulse is applied to the control grid of the tube under test. The bias voltage is sufficient to keep the tube cutoff except during the pulse, and the peak grid voltage obtained during the pulse is varied by adjusting the bias voltage. The circuit schematic used for the pulse tests is shown in drawing A-30903. The plate, suppressor-grid, or screen-grid current may be obtained by measuring the peak amplitude of the voltage pulse across the resistor connected to that electrode. The TS-239/U oscilloscope is used to measure the amplitude of the pulse. By varying E_{c3} and keeping both the input-pulse amplitude and the control-grid bias constant, the electrode currents may be measured as a function of the suppressor-grid voltage.

Plate current for the five tubes as a function of control-grid voltage for a screen-grid voltage of 100 volts, zero suppressor voltage, and a plate of 150 volts is shown in drawing SA-38257-G. Plate current as a function of suppressor-grid voltage for zero control-grid voltage is shown in drawing SA-38259-G. The screen-grid current as a function of suppressor-grid voltage is not shown, but it increases from an average of 36 milliamperes at zero to an average of 51 milliamperes at values of suppressor-grid voltage below cutoff. The cutoff voltage may be defined as the grid voltage necessary to reduce the plate current to 5 per cent of the values measured at zero grid voltage. The control-grid cutoff is between -8 and -9 volts and the suppressor grid cutoff is between -8 and -10 volts. Tube number 8, which evidently has a "hole" in its suppressor, does not cut off at all, however. The zero-grid plate current for these tubes is between 22 and 25 milliamperes.

Drawing SA-38263-G shows plate current for tube number 11 as a function of positive as well as negative suppressor voltages. The curve shows that the plate current increases from 23 milliamperes at zero to 43 milliamperes at a positive suppressor voltage of 15 volts. In this case the screen current decreases from 38 milliamperes to 17 milliamperes. The control-grid-to-plate transfer characteristic for tube number 11 for a positive suppressor voltage of 15 volts is shown in drawing SA-38261-G.

Drawing SA-38262-G shows plate current of tube number 11 as a function of control-grid voltage for screen and plate

voltages of 250 volts and a suppressor voltage of 35 volts. The zero-grid plate current is about 110 milliamperes. Note, however, that the cutoff voltage is about -20 volts. At suppressor voltages this high, negative suppressor-grid currents were observed, indicating the occurrence of secondary emission.

Type SR-1030, Test No. C4527

Also on August 19, five type SR-1030 tubes, test no. C-4527, were received with the following numbers: 1, 7, 9, 10 and 12. The characteristics of these tubes were measured as described previously.

Plate current for the five tubes as a function of control-grid voltage for a screen-grid voltage of 100 volts, zero suppressor voltage, and a plate voltage of 150 volts is shown in drawing SA-38260-G. Plate current as a function of suppressor-grid voltage for zero control-grid voltage is shown in drawing SA-38258-G. The screen current as a function of suppressor-grid voltage is not shown, but it increases from an average value of 30 milliamperes at zero to an average of 49 milliamperes at values of suppressor-grid voltage below cutoff. Tube number 7 appears to have had an internal short, and measurements on this tube may be disregarded. The control-grid cutoff voltage is between -8 and -9 volts and the suppressor grid cutoff voltage is between -10 and -12 volts. Note that the suppressor grid cutoff voltage is several volts more negative than for test number 4523. Evidently this allows more zero-grid plate current, since the zero-grid plate current is 27 to 30 milliamperes as compared with 22 to 25 milliamperes for test number 4523.

The control-grid-to-plate and suppressor-grid-to-plate transfer characteristics of tube number 9 for screen and plate voltages of 150 volts are shown in drawings SA-38266-G and SA-38267-G. The control-grid cutoff voltage is -12 volts and the suppressor-grid cutoff voltage is -13 volts. The zero-grid plate current is about 50 milliamperes.

The average control-grid cutoff voltage as a function of screen voltage is shown in drawing SA-38264-G. The curve shows that the control-grid cutoff voltage is about one-twelveth of the screen voltage. The suppressor-grid cutoff voltage, however, is a function of both the screen and plate voltages. Suppressor-grid cutoff voltage as a function of plate voltage for a screen voltage of 100 volts is shown in drawing SA-38268-G. This curve is for tube number 9 only.

A plate characteristic for tube number 10 is shown in drawing SA-38265-G. The characteristic was obtained with zero control grid and suppressor-grid voltages and a screen voltage of 100 volts. Note that the plate resistance is quite low, about 12,500 ohms.

Type SR-1030A, Test No. C-4543

On September 4, eight type SR-1030A, test number C-4543, tubes were received with the following numbers: 2,4,11,12,13,16,18 and 21.

The static transfer characteristics of tube number 2 were measured using a point-by-point method. Drawing SA-38291-G shows the control-grid-to-plate transfer characteristic for a screen voltage of 100 volts, zero suppressor voltage, and a plate voltage of 150 volts.

Drawing SA-38292-G shows the suppressor-grid-to-plate transfer characteristic for zero control-grid voltage. The control-grid cutoff voltage is -5.8 volts and the suppressor grid cutoff voltage is -7.8 volts. The zero grid plate current is 11.2 milliamperes. Table I lists the individual and average zero-grid plate current, I_b, the control-grid cutoff voltage, E_{co_1}, and the suppressor-grid cutoff voltage, E_{co_3}.

TABLE I
Characteristics of Tube Type SR-1030A,
Test No. C-4543

Tube No.	I_b ma	E_{co_1} v	E_{co_3} v
2	11.2	-5.8	-7.8
4	10.8	-6.8	-8.0
11	10.2	-5.4	-7.9
12	10.8	-6.1	-7.1
13	10.8	-5.6	-7.2
16	11.5	-5.3	-8.3
18	11.8	-6.0	-7.5
21	11.4	-6.5	-8.0
	11.1	-5.9	-7.7

Type SR-1030

Also on September 4, eight type SR-1030, test number C-4573, tubes were received with the following numbers: 1, 2, 8, 7, 9, 10, 19 and 22.

The static transfer characteristics of tube number 1 are shown in drawing SA-38289-G and SA-38290-G. Table II lists the characteristics of the tubes of test number C-4673.

These data show no appreciable difference between the tubes of test number C-4673 and the tubes of test number C-4543.

The transfer characteristics of the tube of test number C-4673 and the tubes of test number C-4543 are not as good as the transfer characteristic of the 6AS6. With 150 volts applied to the screen and plate of the 6AS6, the control-grid cutoff is -5 volts, the suppressor-grid cutoff is -8 volts, and the zero-grid plate current is 14 to 20 milliamperes.

TABLE II
Characteristics of Tube Type SR-1030.
Test No. C-4673

Tube No.	I_b ma	$E_{c_{01}}$ v	$E_{c_{03}}$ v
1	12.1	-5.3	-8.7
2	11.7	-6.8	-8.5
7	12.1	-5.7	-8.3
8	10.6	-5.4	-7.7
9	12.6	-6.1	-8.0
10	11.3	-6.0	-8.0
19	11.9	-6.6	-6.9
22	11.7	-5.6	-8.7
	11.7	-5.9	-8.1

David R. Brown rp
D. R. BROWN

Norman H. Taylor
N. H. TAYLOR

DRB/NHT/rp

6345
Memorandum M-103 September 17, 1947

List of Drawings

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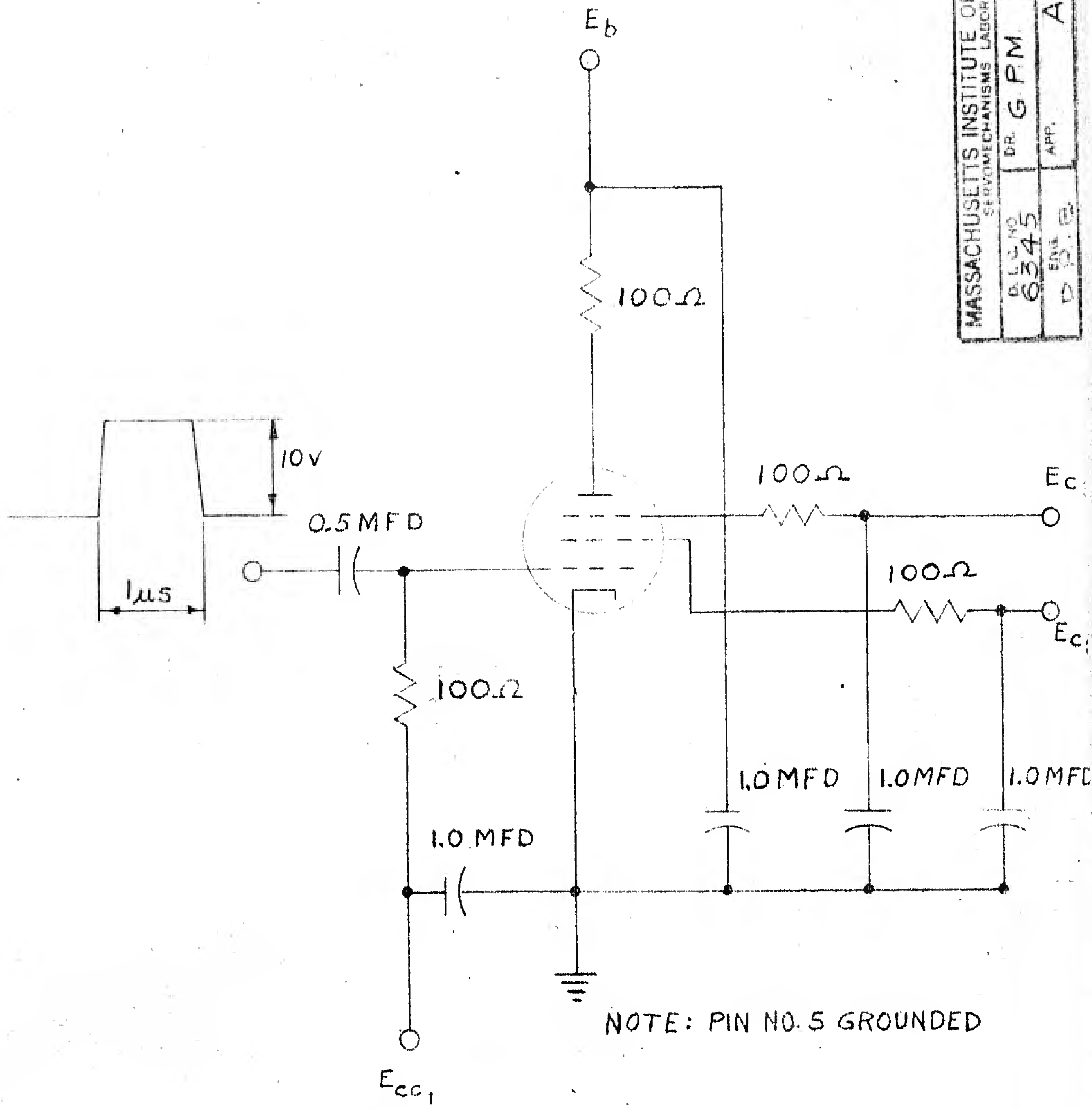
" "	SA-38259-G
" "	SA-38263-G
" "	SA-38261-G
" "	SA-38262-G
" "	SA-38260-G
" "	SA-38258-G
" "	SA-38266-G
" "	SA-38267-G
Control-Grid Cutoff vs. Screen-Grid Voltage	SA-38264-G
Suppressor-Grid Cutoff vs. Plate Voltage	SA-38268-G
Plate Characteristic	SA-38265-G
Transfer Characteristic	SA-38291-G
" "	SA-38292-G
" "	SA-38289-G
" "	SA-38290-G

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY

B.L.C. NO. 6345	DR. G.P.M.	CK.
ENG. D.D.B.	APP.	A-30903

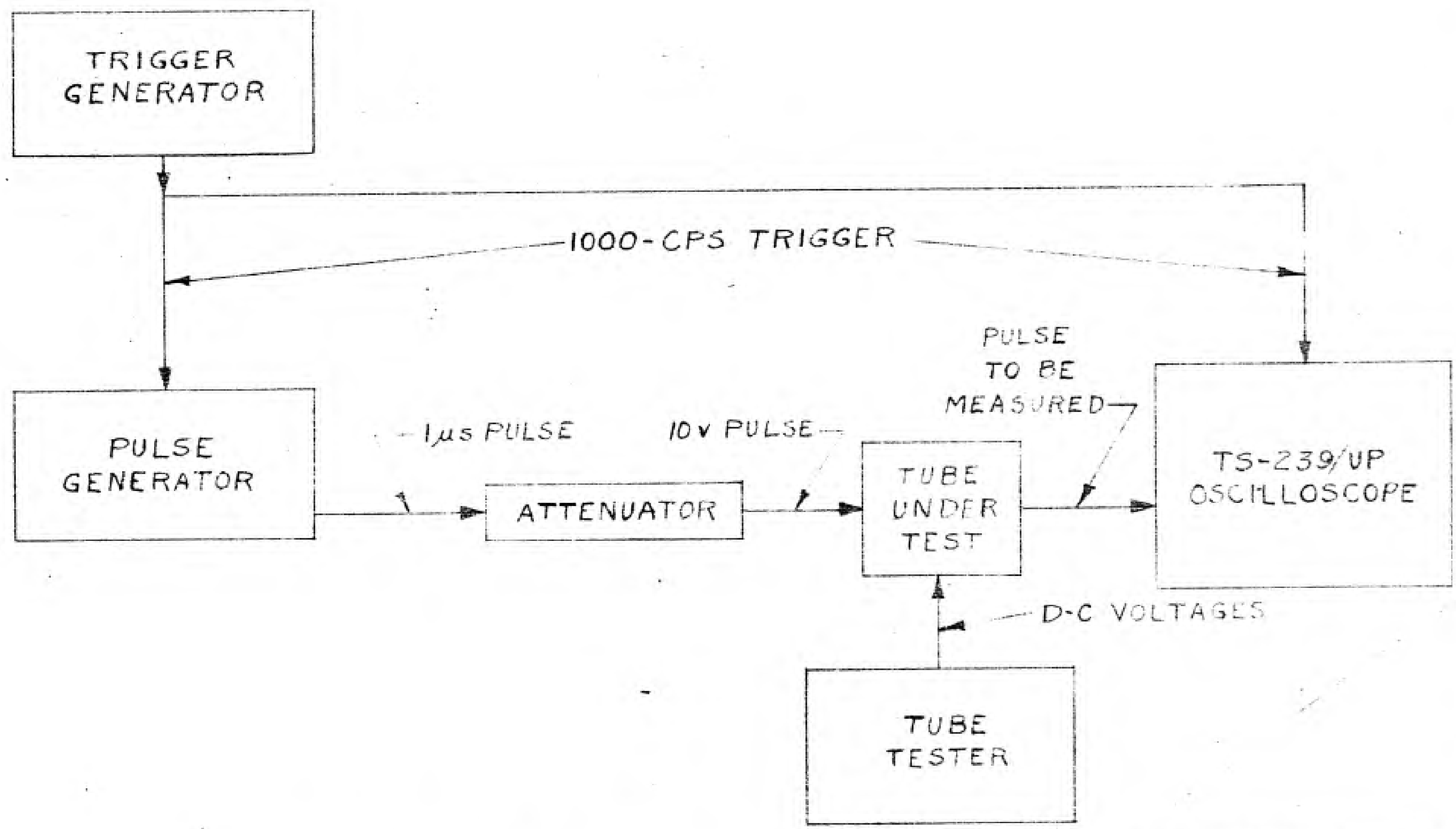
USED IN 6345 MEMO NO. M-103



CIRCUIT SCHEMATIC USED
FOR PULSE TESTS

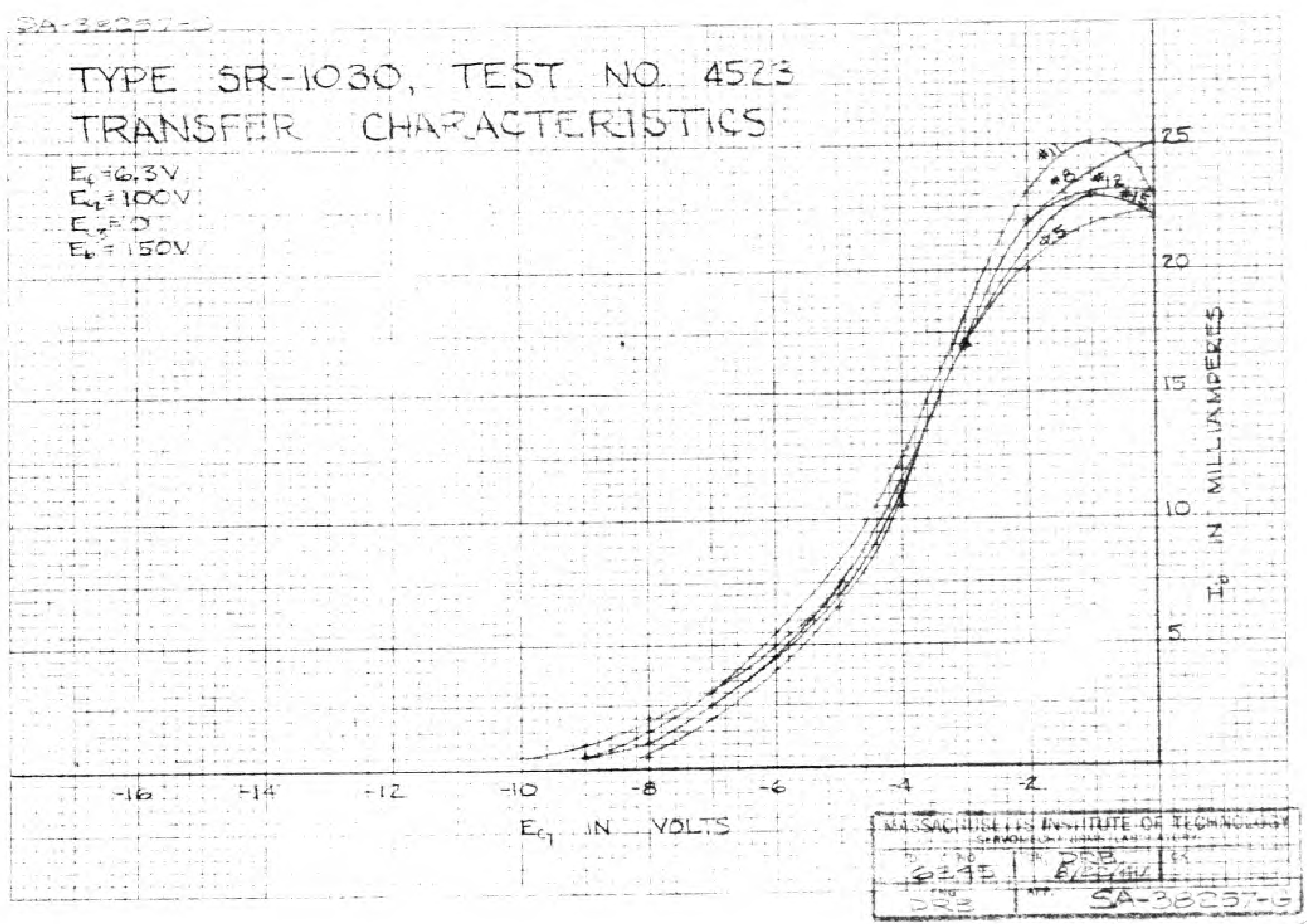
A-30903

A-30904 USED IN 6345 MEMO NO. M-102



BLOCK SCHEMATIC OF ARRANGEMENT
FOR PULSE TESTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY SERVOMECHANISMS LABORATORY		
D.I.C. NO. 6345	D. G.P.M.	CK.
ENG. D.R.B.	APP.	A-30904

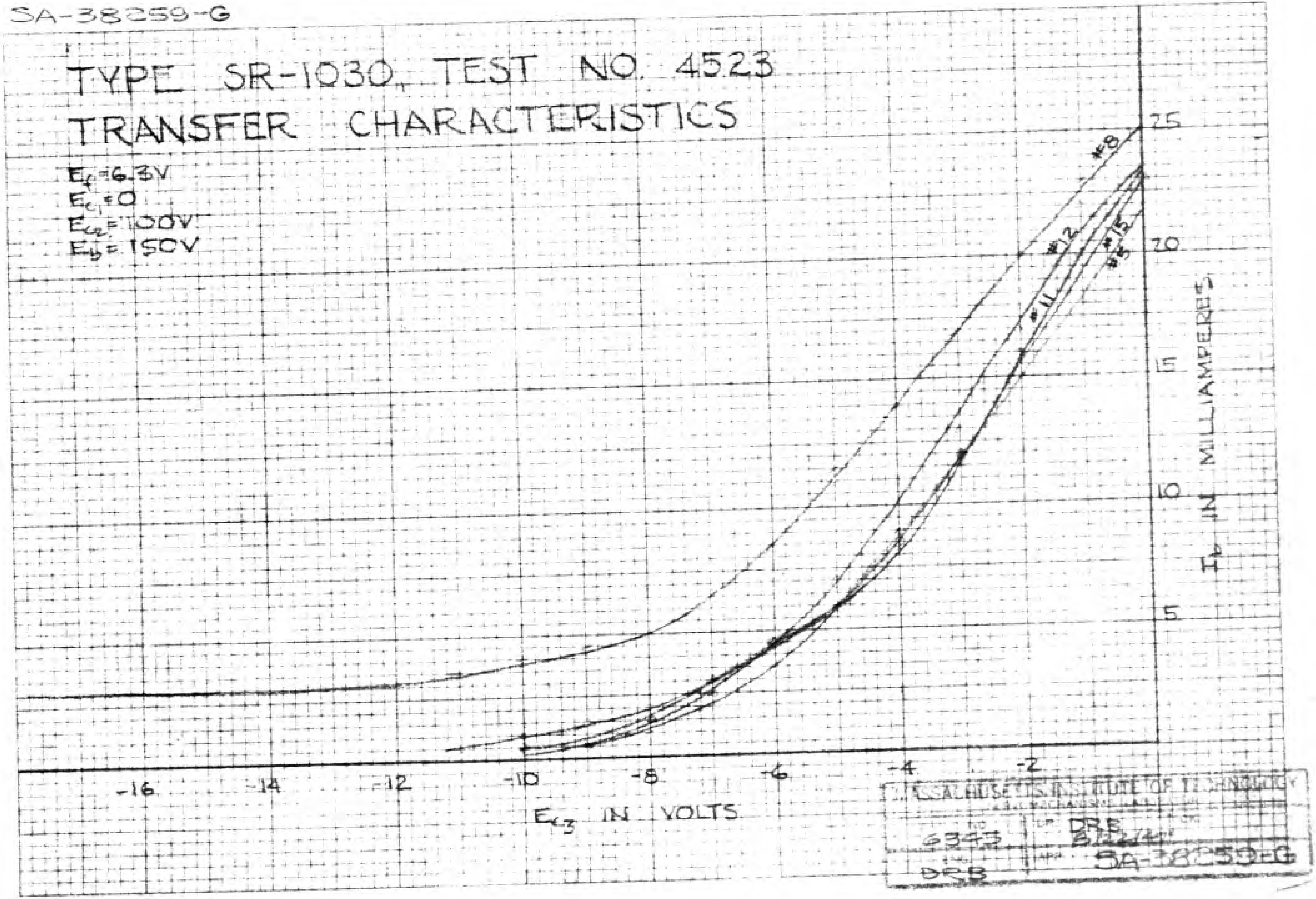

SA-38257-G
TYPE SR-1030, TEST NO. 4523
TRANSFER CHARACTERISTICS
Ef = 6.3V
Ec2 = 100V
Ec3 = 0
Eb = 150V
#1
#8
#12
#15
#5
25
20
15
10
5
Ib IN MILLIAMPERES
-16
-14
-12
-10
-8
-6
-4
-2
Ec1 IN VOLTS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY
6295
DRB
SA-38257-G

NO. 340-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.

USED IN 6345 MEMO M-103

SA-38259-G

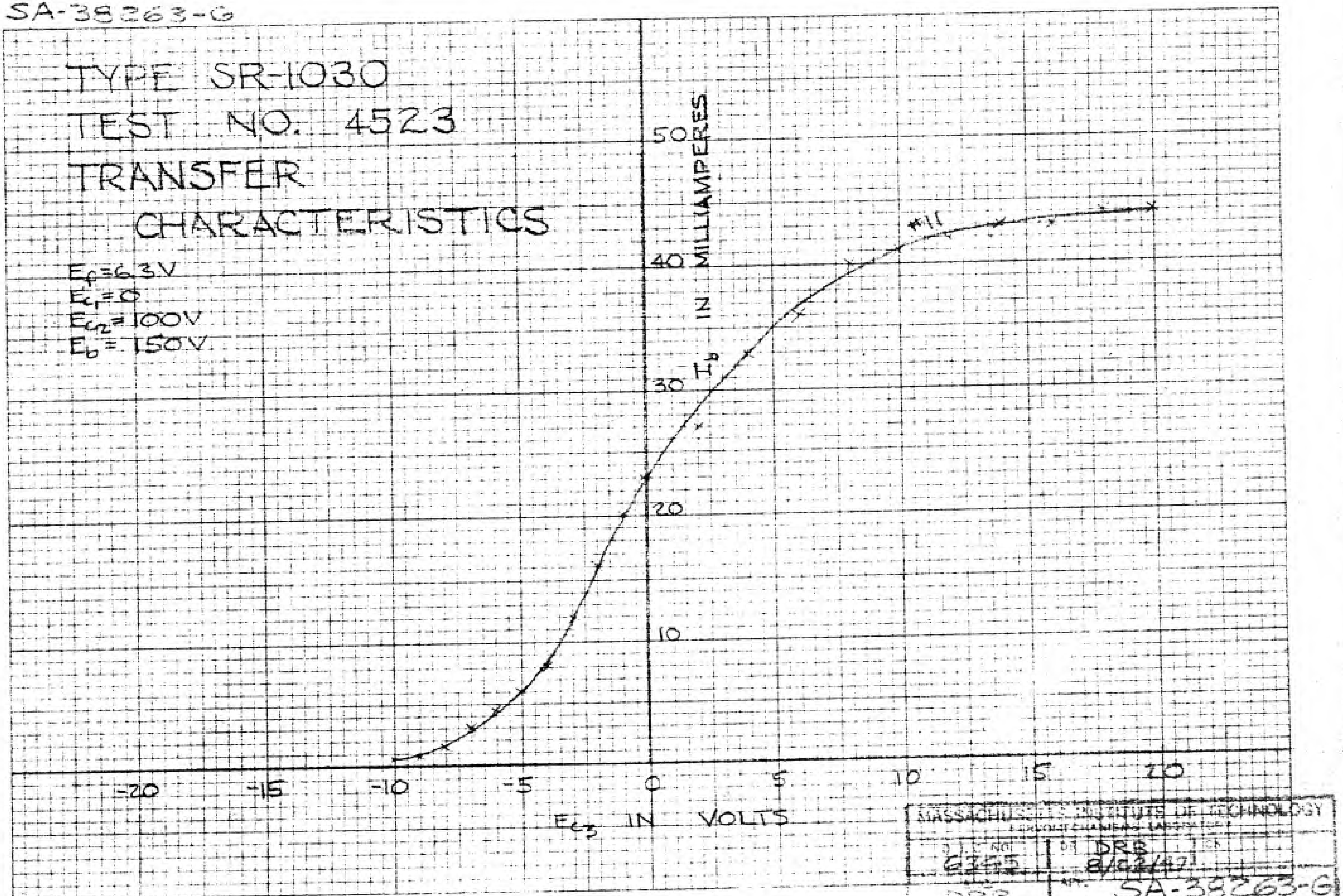


NO. 340-10 DIETZGEN GRAPH PAPER
10 X 10 PER INCH

EUGENE DIETZGEN CO.

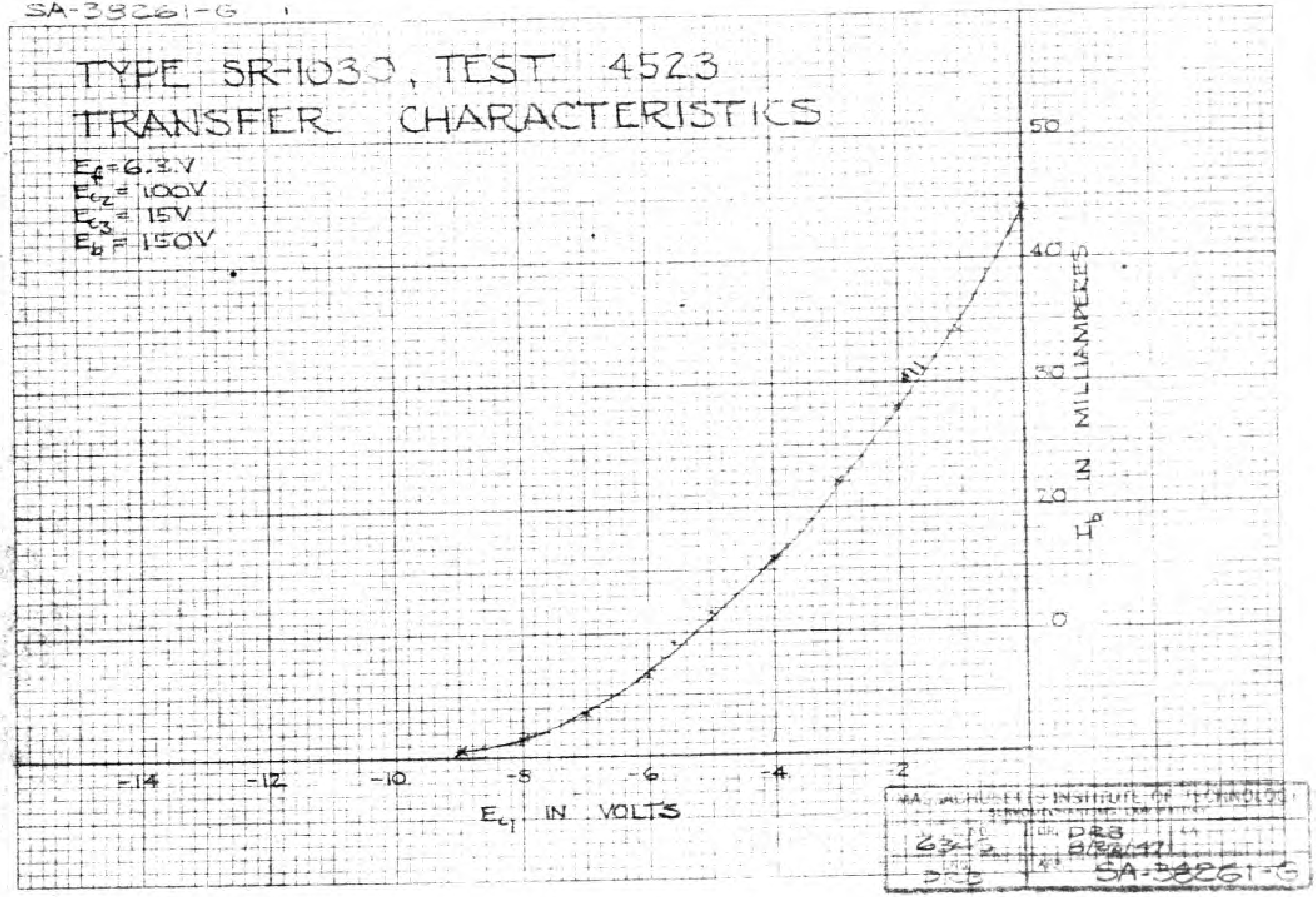
USED IN 6345 MEMO M-103

SA-38263-G



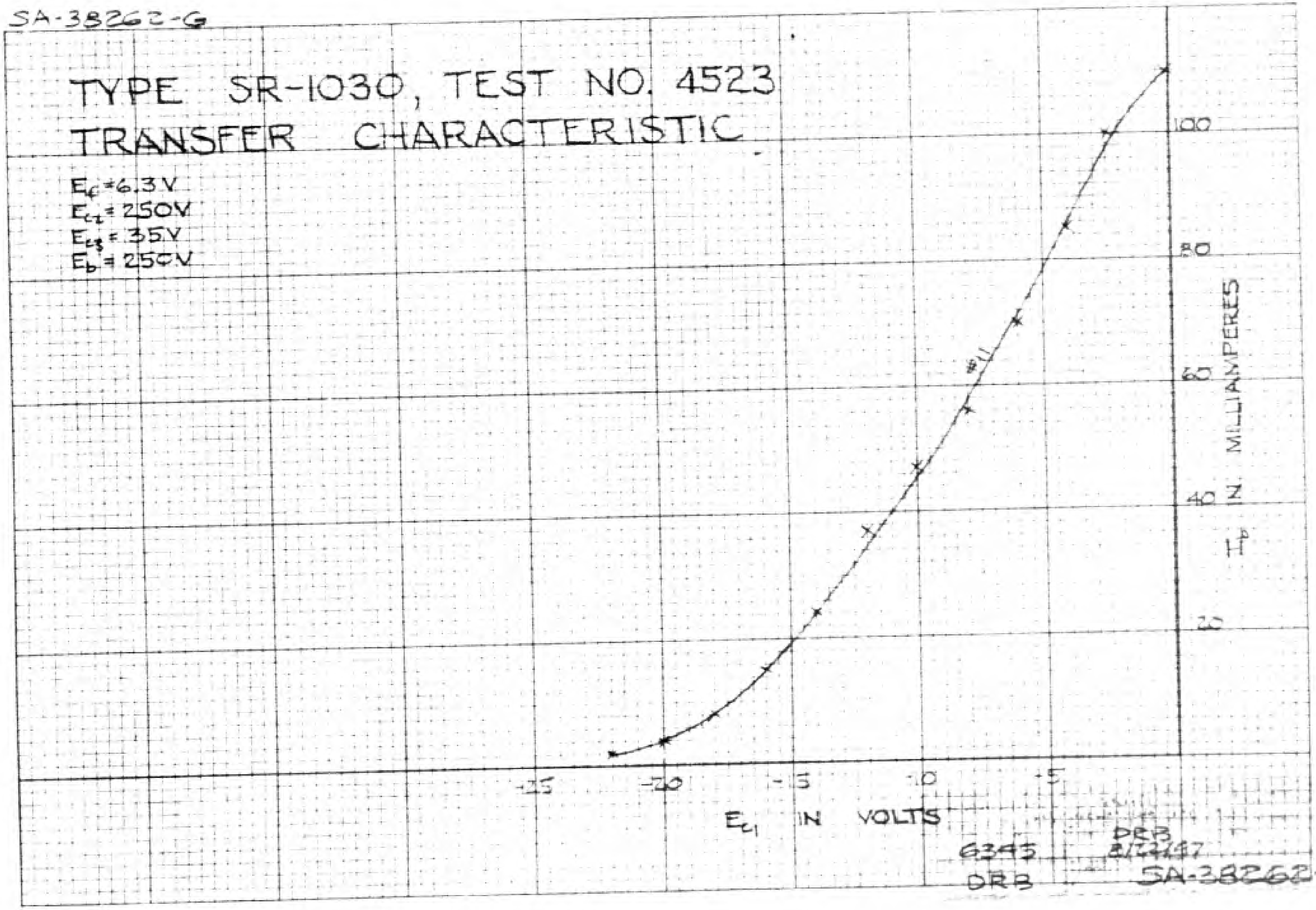
USED IN 6345 MEMO M-103

SA-38261-G



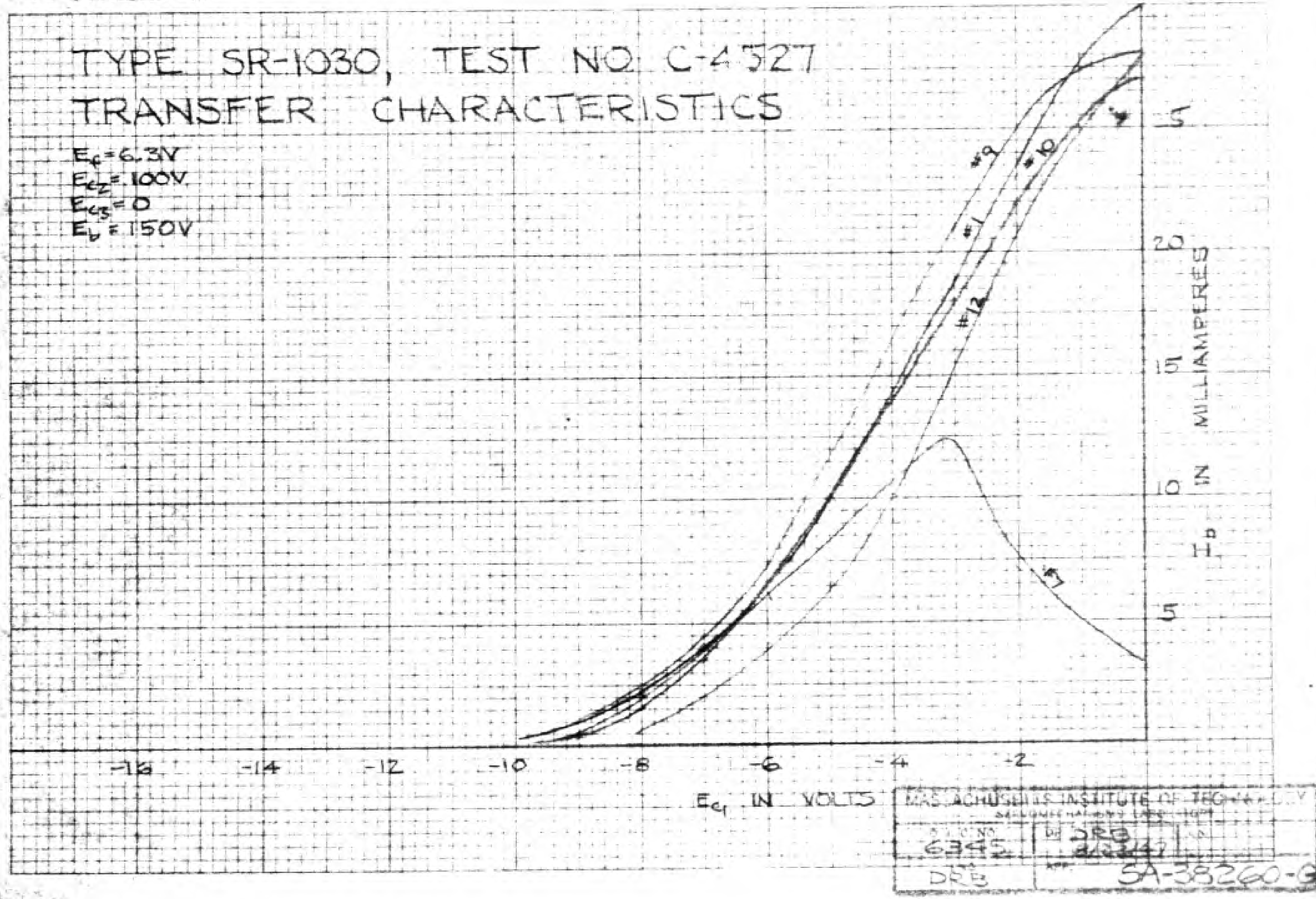
USED IN 6345 MEMO M-103

SA-38262-G



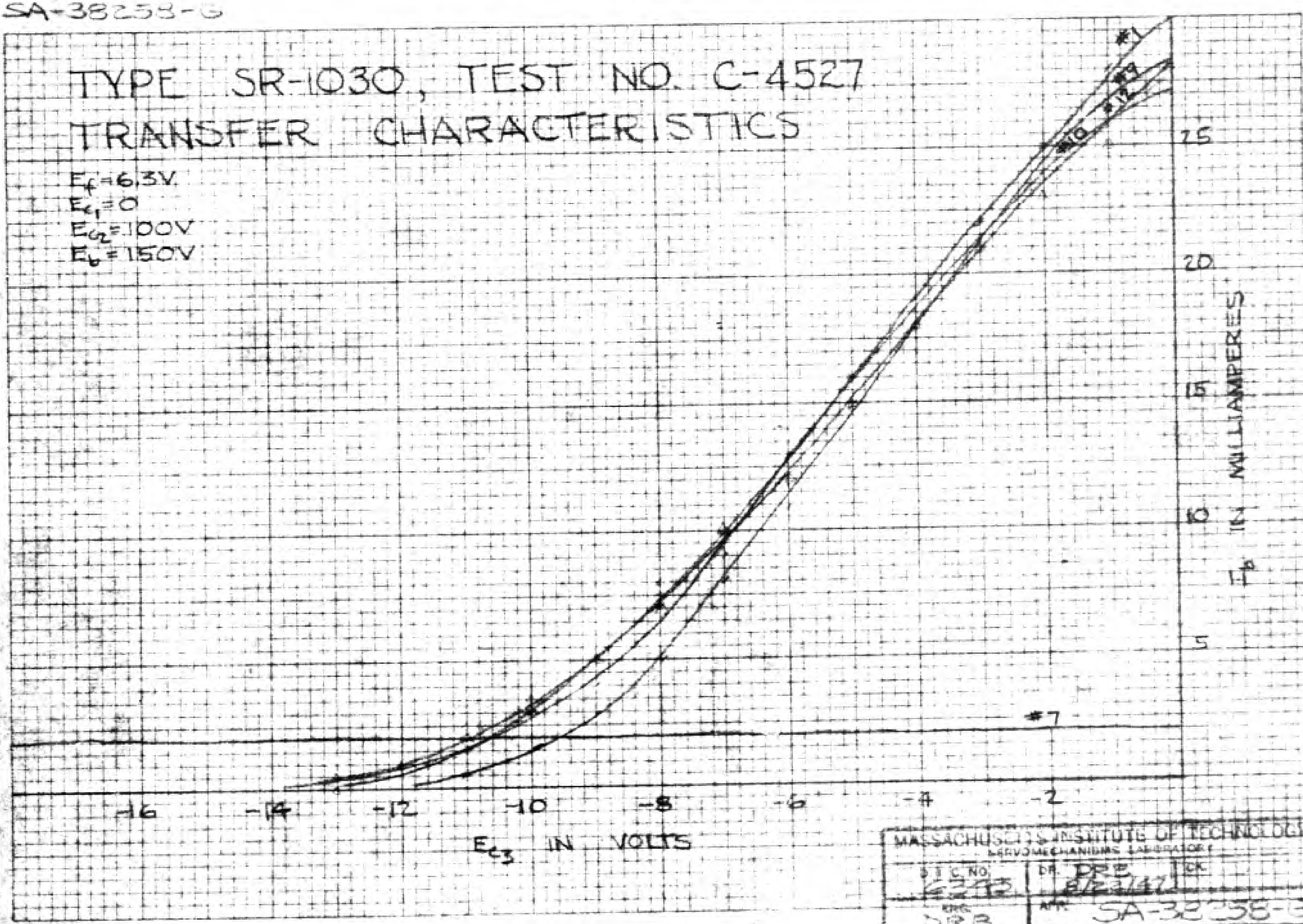
SA-38260-G

USED IN 6345 M-102



USED IN 6345 MEMO M-103

SA-38258-G



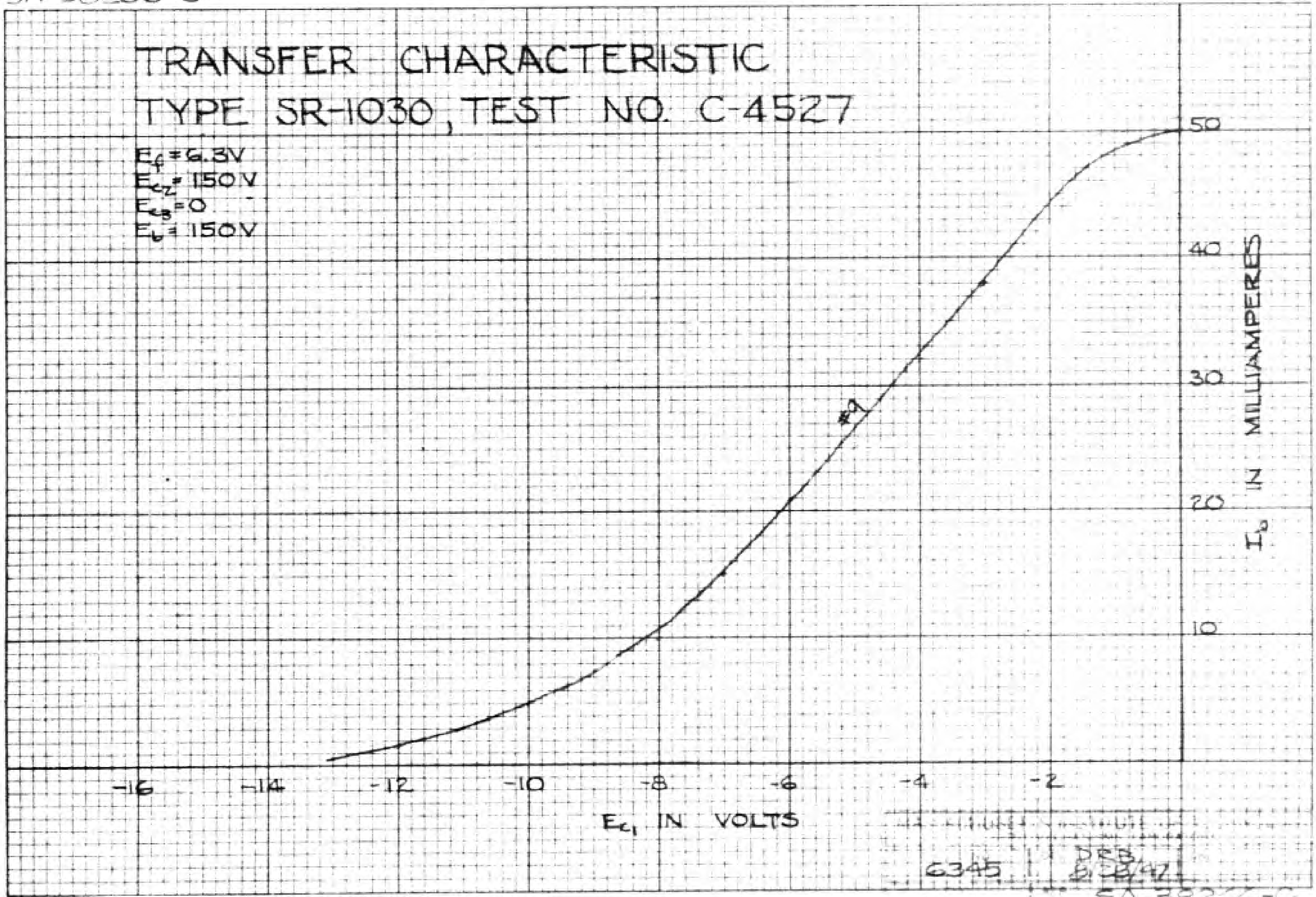
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY

D.I.C. NO.	DR.	CK.
6345	DRB 8/23/47	
ENG. DRB	APP.	SA-38258-G

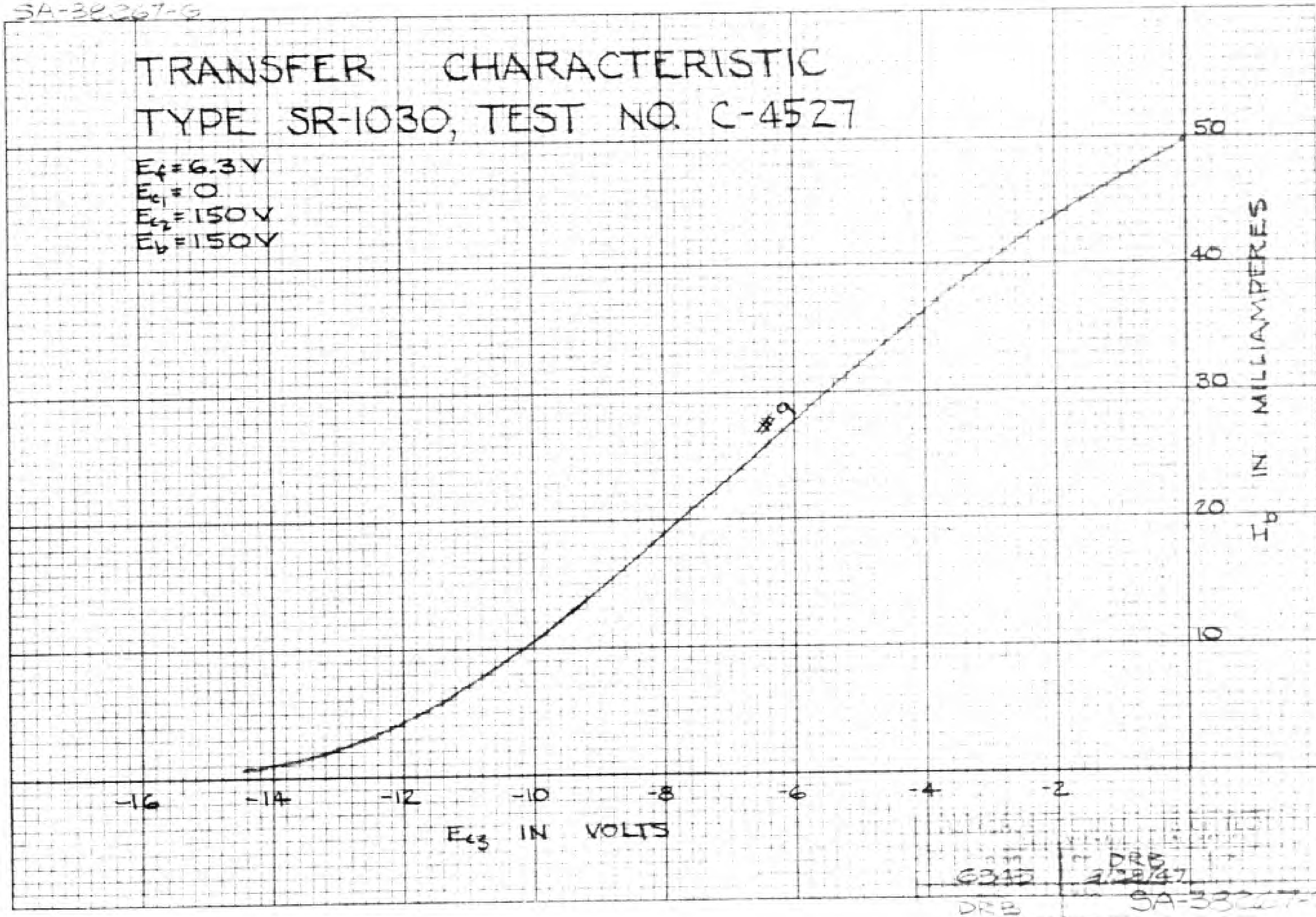
KEUFFEL & ESSER CO., N. Y. NO. 359T-5G
10 X 10 to the inch
MADE IN U.S.A.

USED IN 6345 MEMO M-103

SA-38266-G

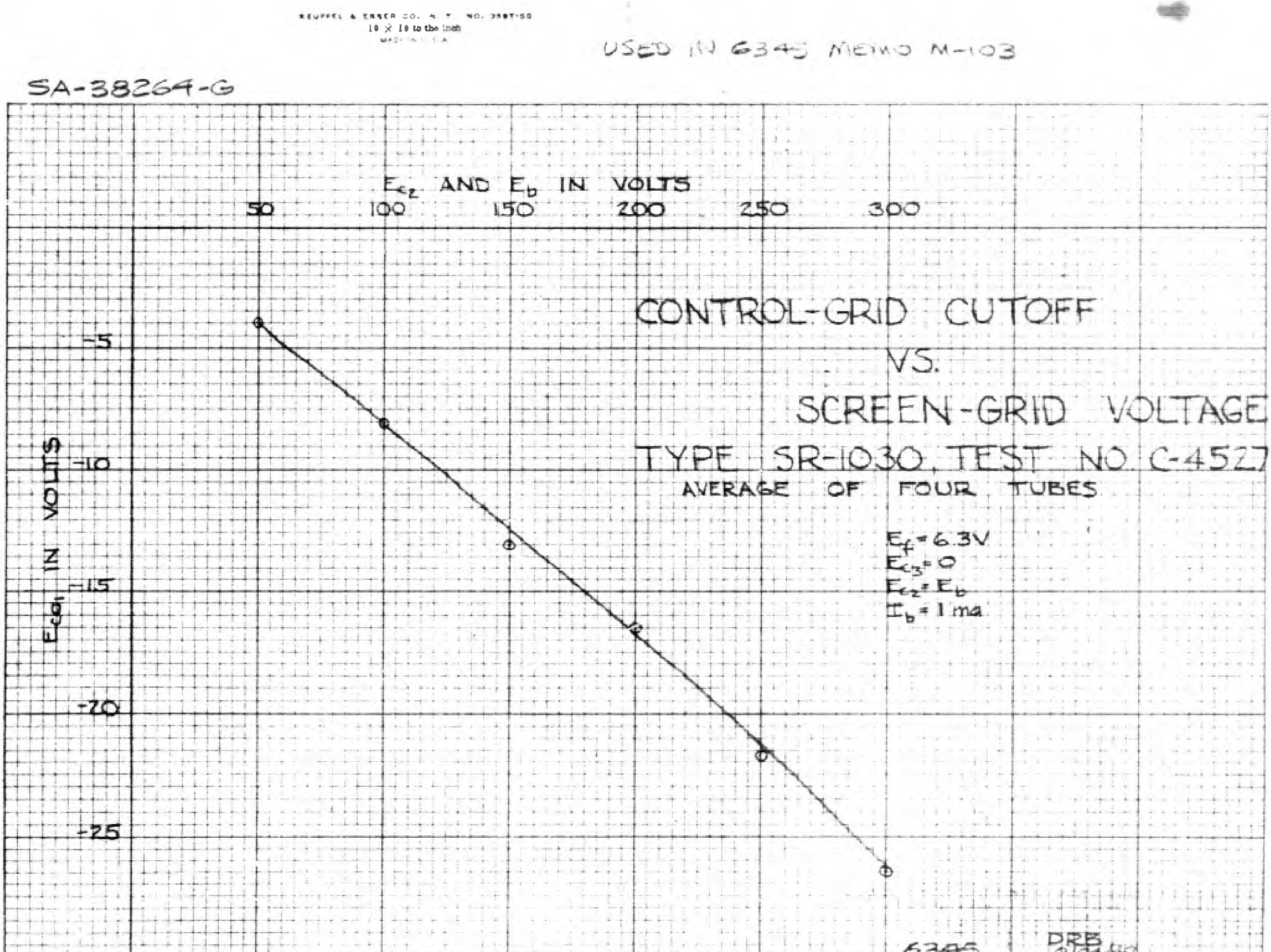


USED IN 6345 MEMO N-103



USED IN 6345 MEMO M-103

SA-38264-G

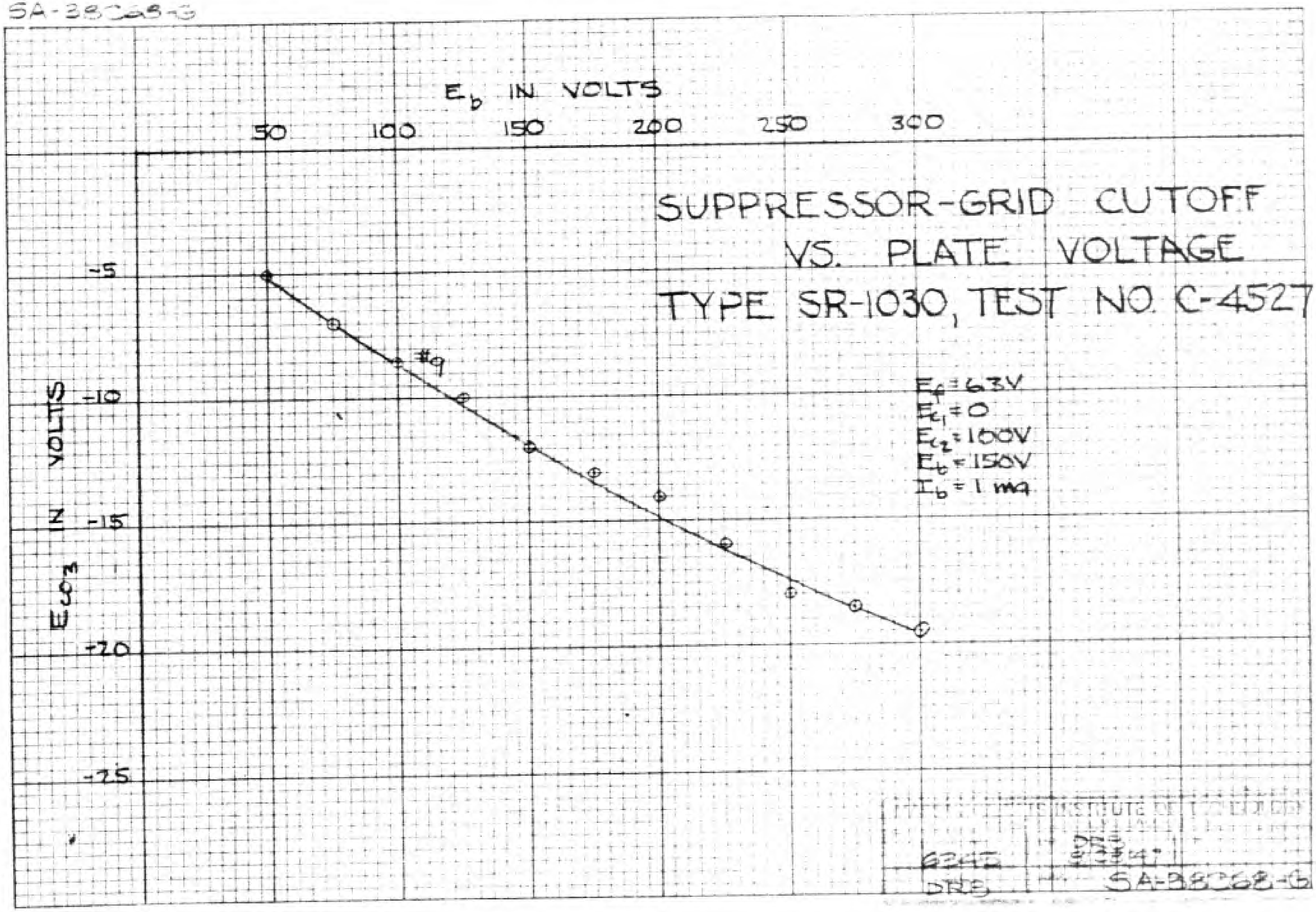


SA-38264-G

KEUFFEL & ESSER CO. N.Y. NO. 358T-5G 10 X 10 to the inch MADE IN U.S.A.

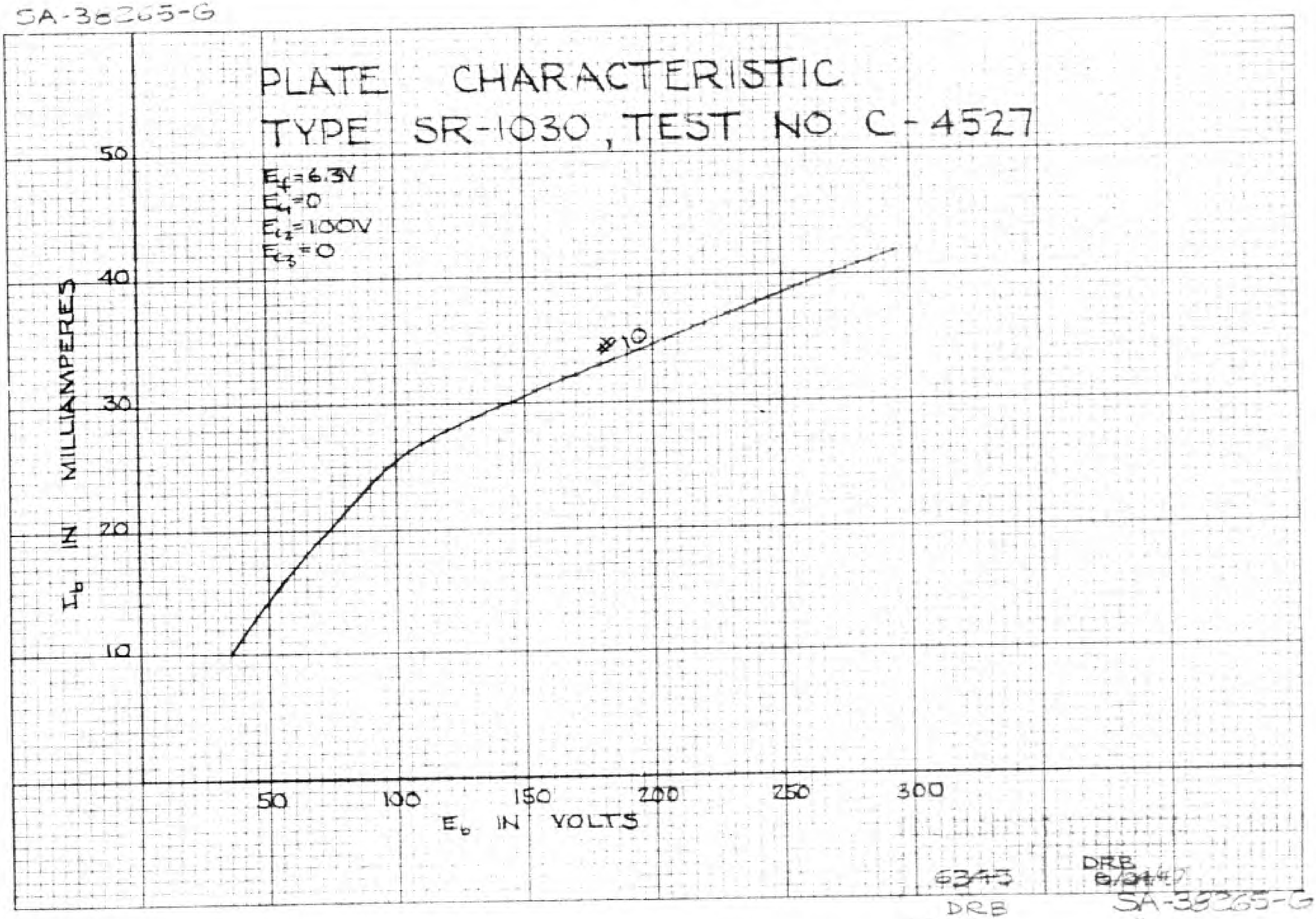
USED IN 6345 MEMO M-103

SA-38068-G



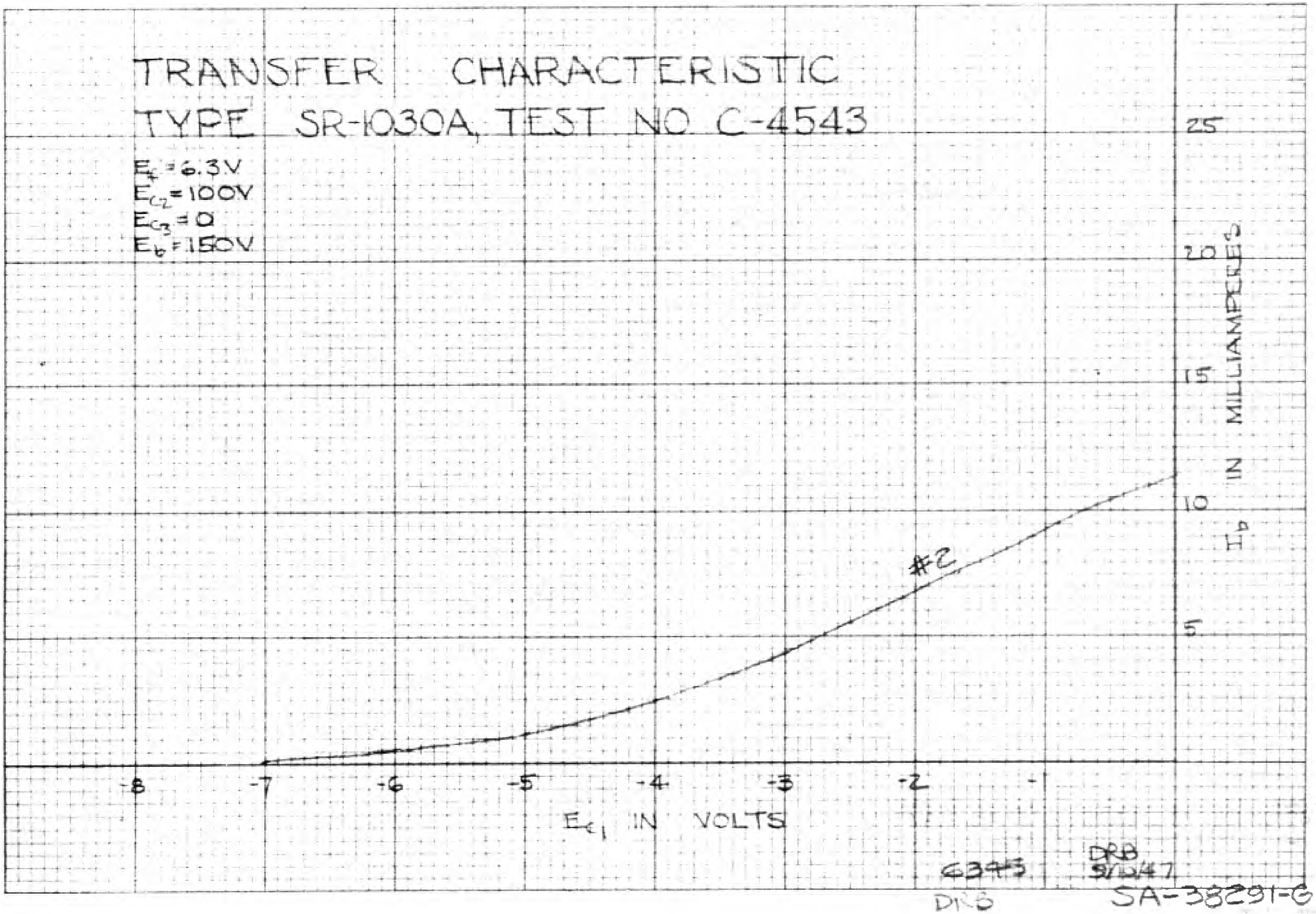
USED IN 6345 MEMO M-103

SA-38365-G



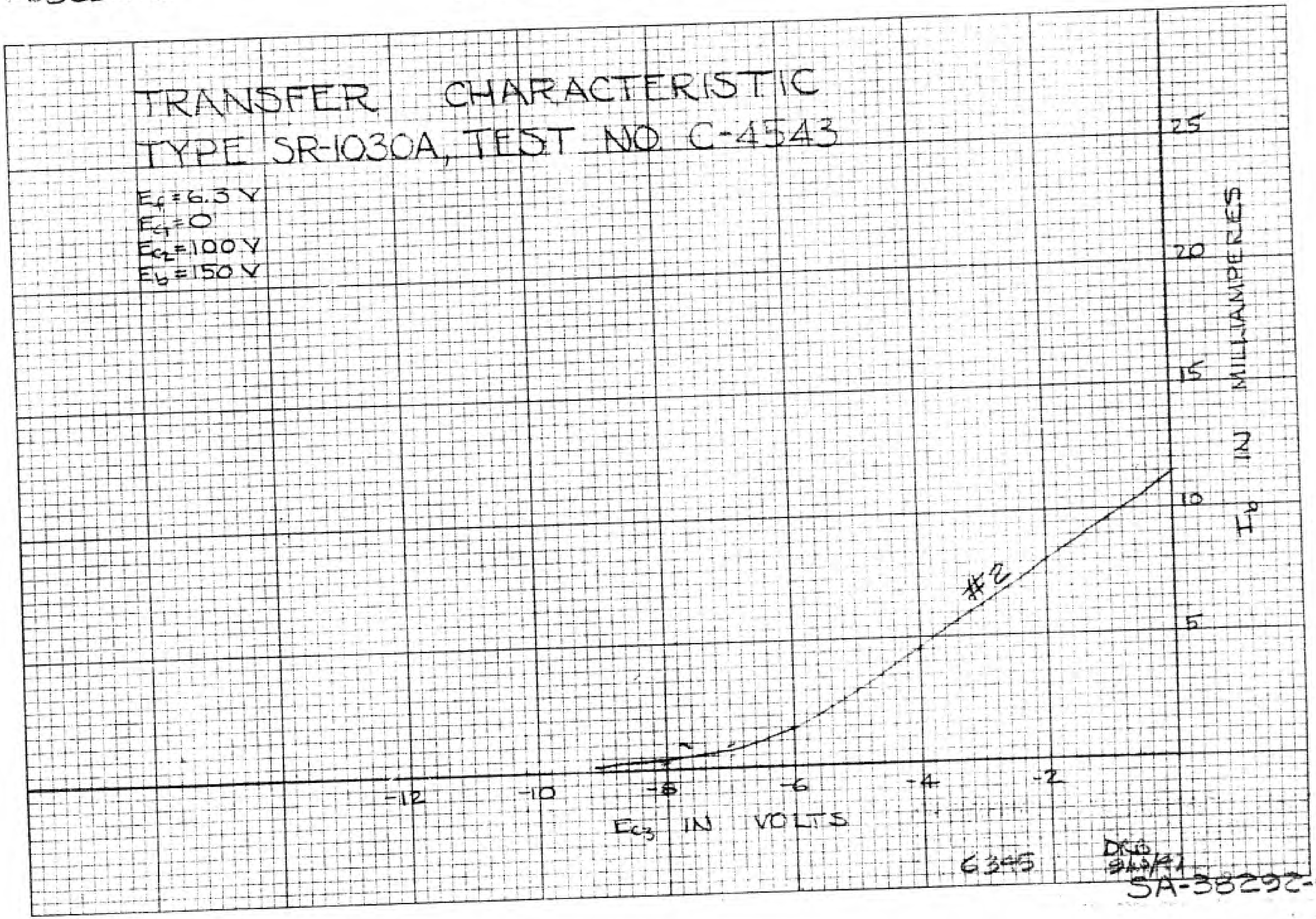
SA-38291-G

USED IN 6345 MEMO M-103



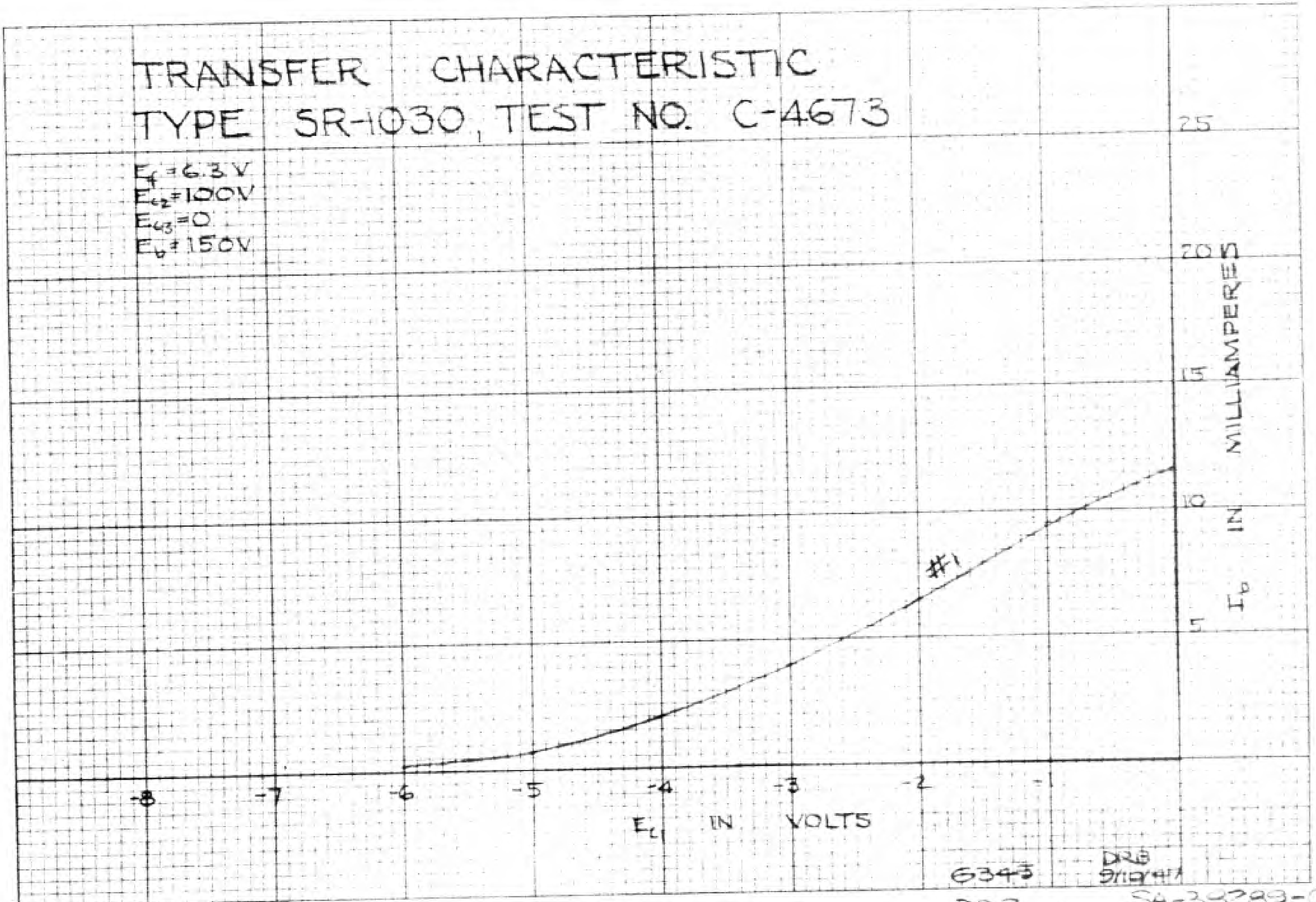
SA-38292-G

USED IN 6345 MEMO M-103



SA-38289-G

USED IN G3-5 MEMO M-103

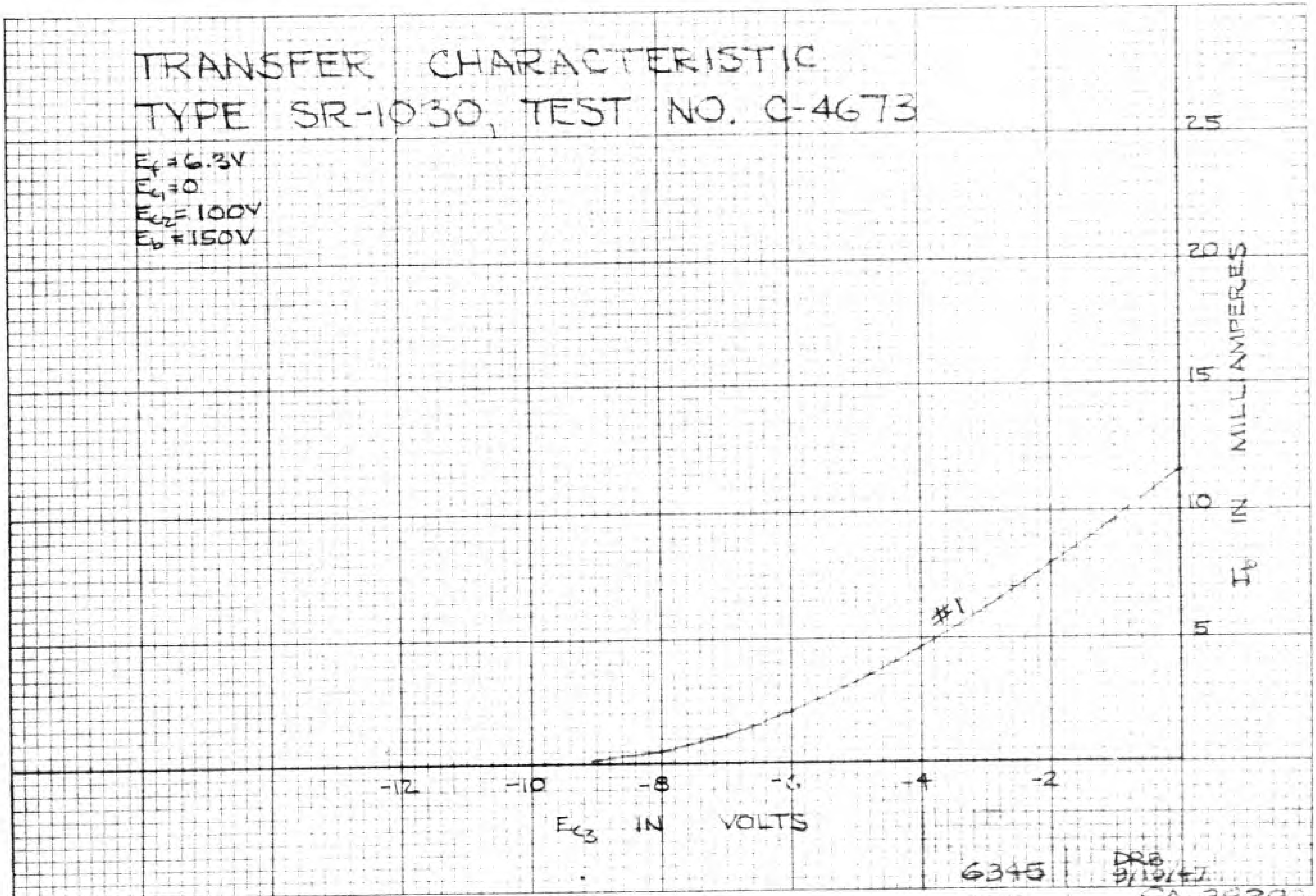


DRB

SA-38289-G

SA-38290-G

USED IN 6345 MEMO M-103



DRB

SA-38290-G

6345
Memorandum M-109

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: GATE-TUBE RESEARCH

To: J. W. Forrester, H. Fahnestock, N. H. Taylor, G. C. Hoberg, H. Kenosian, E. W. Sard.

From: David R. Brown

Date: October 2, 1947

Tube Program

1. Obtain static transfer characteristics for the four C-4523 tubes, 5, 11, 12, and 15. E_f=6.3V, E_{c2}=100V, E_{c3}=0.

2. Design gate circuit to produce a positive output pulse. With suppressor grounded, test this circuit with 0.1-μs half-sine-wave pulses. Make sure that no signal bias is present or at least know just how far the control grid is being driven. If time permits, try also 0.05-μs, 1.5-μs, and 2.0-μs pulses. Repeat with pulses which are as nearly rectangular as obtainable. Get input-output curves for the four tubes available.

3. Place four gate circuits in series and investigate the wave shape in the chain. This will yield data on the relative merits of a half-sine-wave or a rectangular pulse. Do this for only one pulse length, probably 0.1-μs.

4. Using the optimum pulse shape, as determined from the previous measurements, design and test a gate circuit to produce a negative output pulse and a gate circuit to work into a step-down transformer, cable, and step-up transformer. Obtain input-output curves for these gate circuits.

5. Design a gate generator, probably a flip-flop, and observe output waveforms of the gate circuits when gate is present or absent.

6. Measure the input capacitances of the gate circuits and investigate the problem of reading into or out of a register.

David R. Brown
David R. Brown

DRB/sp

6345

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: PRELIMINARY SPECIFICATION FOR TUBE TYPE SR-1030

To: J. W. Forrester, H. Fahnestock, E. R. Boyd, M. H. Taylor, N. Rochester (Sylvania, Boston), N. L. Kiser, (Sylvania, Emporium)

From: David R. Brown

Date: October 17, 1947

Preliminary Specifications for Tube Type SR-1030.

Test Condition I:

$E_f = 6.3v$
$Ec_1 = 0$
$Ec_2 = 80v$
$Ec_3 = 0$
$E_b = 150v$

The plate current, I_{b1} shall have a nominal value of 40 milliamperes and shall not be less than 35 milliamperes.

Test Condition II:

$E_f = 6.3v$
$Ec_2 = 80v$
$Ec_3 = 0$
$E_b = 150v$
$I_b = 2ma$

The control-grid voltage, E_{c_1}, necessary to reduce the plate current, I_b, to 2 milliamperes shall not be more negative than -11 volts.

Test Condition III:

$E_f = 6.3v$
$Ec_1 = 0$
$Ec_2 = 80v$
$E_b = 150v$
$I_b = 2ma$

The suppressor-grid voltage, Ec_3, necessary to reduce the plate current, I_b, to 2 milliamperes shall not be more negative than -9 volts.

Power Ratings:

The tube shall safely dissipate the heat generated when the control grid is pulsed from -15 volts to zero volts with a duty cycle of 1/12. The suppressor gird may either be at -15 volts or zero volts.

Capacitances:

The nominal input capacitance, output capacitance, and capacitance from suppressor-grid to plate shall be no greater than in the SR-1030, test number C-4999.

Signed David R. Brown
David R. Brown

DRB:sp

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: SECOND TRIP TO EMPORIUM

To: Jay W. Forrester

From: David R. Brown

Date. October 20, 1947

The morning was spent with Mr. H. L. Kiser and Mr. Roger Slinkman in Kiser's office. Also present were N. Rochester of Sylvania, Boston, N. H. Taylor and D. R. Brown of M. I. T.

Sylvania has made a new gate tube based on the 5545 construction. This is the SR-1030, test number C-4999. The tube has the same grid spacing on all three grids. The spacing and wire diameter is as small as they feel they can go and still give us a reliable tube. The control and screen grids are aligned as in beam-type tubes. The suppressor grid is wound in the opposite sense. Gold plated grid wire and copper laterals are used. No tooling is required to produce the tube. This should keep the cost down and reduce the delivery time. Mr. Kiser emphasized that they have continually kept the problem of long life in mind and have given us the best long-life construction they can. Kiser feels, however, that he cannot estimate the life and a life test is the only way to make sure that this is a long-life tube.

They showed us the bridge characteristics of the lot that they have made and also the transfer characteristics for tube No. 1. At a screen voltage of 100 volts, tube No. 1 gave 49 ma. plate current at zero grid. The control grid cutoff is -12 volts and the suppressor grid cutoff is -9 volts.

Tube No. 10 looked like a more average tube. We took it and, in an effort to increase (make less negative) the cutoff voltages, made measurements to determine the transfer characteristics at a screen voltage of 80 volts. We did this because we felt that we could stand some reduction in the zero-grid plate current, particularly if the cutoff could be brought in. Under these conditions, tube No. 10 gave a zero-grid plate current of 41 ma. The control-grid cutoff was -11 volts and the suppressor-grid cutoff was -8 volts.

We felt that the lower cutoff on the control-grid would not be an insurmountable difficulty. We would rather see the sharper cutoff on the suppressor grid so that the gate tube can be controlled directly from a flip-flop. The control grid is often driven from a buffer amplifier where there is plenty of amplitude available. In many cases, the control grid is driven from the bus. The thing to keep in mind, then, is the minimum signal amplitude on the bus. We can, with the control-grid cutoff of -11 volts, use the tube in our present design, i.e., with -15 volts fixed bias. However, if Sylvania can increase the cutoff, we will be safer.

Emporium will change the grid-cathode spacing in an effort to increase the cutoff on the control grid. Certainly they can prevent the cutoff from decreasing below -11 volts.

We decided to take some samples of this tube back to M.I.T. and make enough measurements to satisfy ourselves that this tube is satisfactory. Emporium is sure that if we decide the tube is O.K., they will be able to produce it. The final decision then, will be made on the basis of this small lot of five tubes: 2, 6, 10, 12, and 13. We will try to give them the O.K. on about October 17th. Then they will make a batch of 100 or 200 tubes and make complete measurements to establish their production specs. By October 31st, they will give us the average characteristics and all the tubes from this batch of 100 or 200.

Any time after that we can order the 3000 tubes we want. They plan to age the tubes for 200 hours. We will get delivery on the 3000 in six or eight weeks. If we want 500 tubes in a hurry for laboratory work we can get them, without ageing, about November 15th.

Sylvania will guarantee to fulfill future orders in a specified minimum time, say 9 months.

The price will be established by their cost department and will probably be in the neighborhood of two or three dollars.

Kiser is preparing, in writing, the guarantee and the price quotation.

Sylvania is making a replacement or near-equivalent of the 6AG7 for Philco television receivers. This is a lock-in known as the 7AD7. We now have data on this tube. The plate current is 2 ma. less than the 6AG7 and the g_m is 9,500 μmho.

The Philco tubes are being made with a cage to reduce the grid-plate capacitance. This cage is giving them trouble in out-gassing the tubes. Since we are not particularly interested in grid-plate capacitance, we would just as soon have them without the cage. Fifty 7AD7's were run thru the production line without the cage. We have 27 of these tubes; the type is 707A. The 707A has an improved cathode and heater construction and several other improvements which should make it better than the 6AG7.

Signed *David R. Brown*
David R. Brown

Distribution:
E. R. Boyd
D. R. Brown
D. J. Crawford
S. H. Dodd
J. C. Ely
R. R. Everett
H. Fahnestock
G. G. Hoberg
E. W. Sard
N. H. Taylor

DRB/ep

6345
Engineering Notes E-73

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: MEASUREMENTS ON THE C-4999 SERIES OF THE SR-1030 GATE TUBE

To: 6345 Engineers

From: Eugene W. Sard

Date: October 22, 1947

Introduction

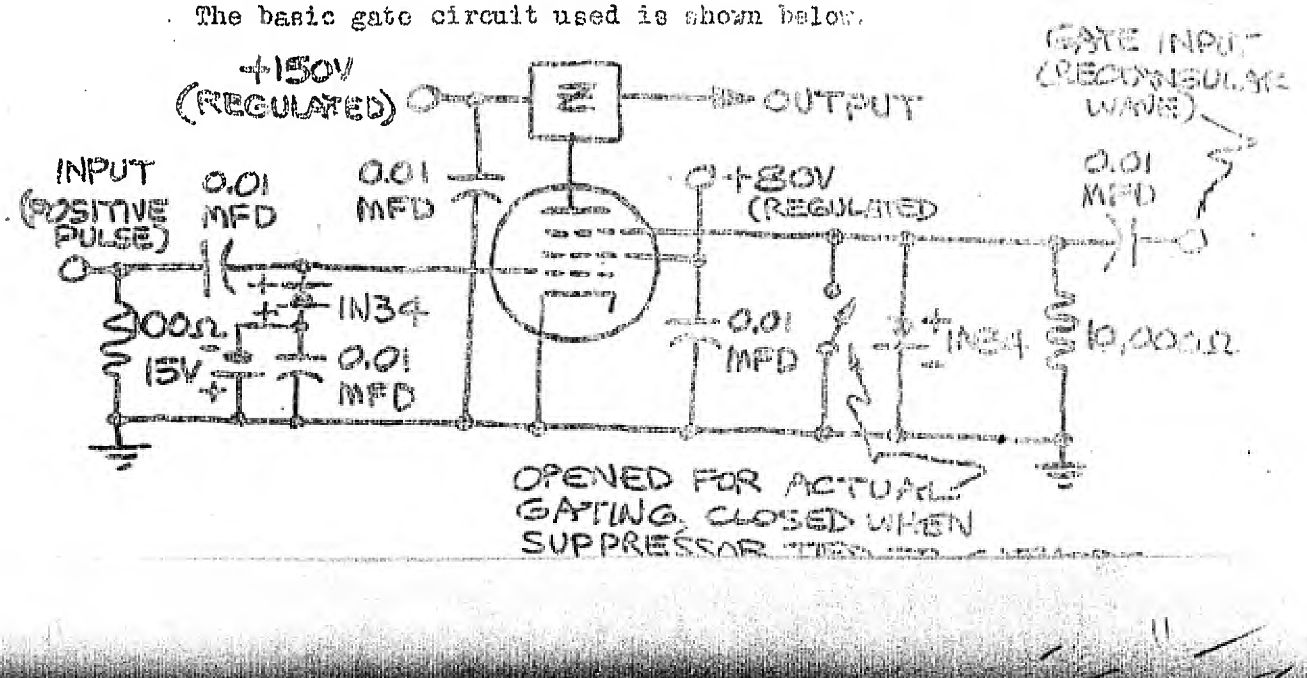
The C-4999 series is the latest and best of the new SR-1030 gate tubes. Five C-4999 series tubes were available for experimentation, and all five proved to have essentially the same characteristics. Drawing A-38302-G shows the static characteristics for tube No. 10 of the C-4999 series.

Three types of gate circuits were used in the course of the work. The first was a gate circuit to produce a positive output pulse, the second was a gate circuit to produce a negative output pulse, and the third was a gate circuit to work into a step-down transformer, cable, and step-up transformer. In addition four gate circuits of the first type were connected in cascade to observe the behavior of a chain of gate tubes. For most of the measurements, the suppressor of the gate tube was tied to cathode. However, actual gating of the suppressor was also tried in the case of the first and second types of gate circuits. The results of actual gating and tying the suppressor to cathode agreed fairly well.

Except where otherwise described, the input to the above gate circuits was a rounded half-sinusoidal positive pulse about 0.1 μs wide at the base, occurring at a repetition rate of either approximately 1 mc. or 2 kc. (The output amplitude of the gate circuits tested was about the same for these two repetition rates).

Experimental Work

The basic gate circuit used is shown below.



1. Gate Circuit to Produce a Positive Output Pulse.

Here Z consists of:

The 22 MMFD in this circuit and in others simulates the load of a following stage.

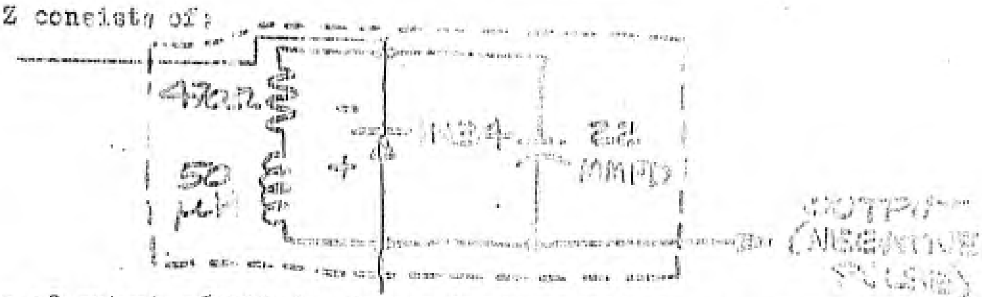
Values of output amplitude versus input amplitude are tabulated below.

Input Amplitude in Volts	7	10	13	15
Output Amplitude in Volts	4	12	21	26

The output pulse was about 0.06 μs wide in contrast to the 0.1 μs wide input pulse.

2. Gate Circuit to Produce a Negative Output Pulse

Here Z consists of:



Values of output amplitude versus input amplitude are tabulated below.

Input Amplitude in Volts	7	10	13	15
Output Amplitude in Volts	4	11	25	31

The output pulse was about the same width as the input pulse (0.1 μs).

3. Gate Circuit to Work into a Step-Down Transformer, Cable, and Step-Up Transformer.

Measurements on this circuit were made by C. G. Hoberg, and the circuit used was similar to that of E-60.

Values of output amplitude versus input amplitude are tabulated below.

Input Amplitude in Volts	8	10	12	14	15	18	20	22	24	26
Output Amplitude in Volts	5½	10	15	18	21	22	22	21	18	16½

In making these measurements, an actual tube load was used instead of a lumped 22 MMFD. condenser. Additional measurements on several of this type of gate circuit connected in cascade are being made, and these new measurements plus more complete information on the above circuit will be published later.

4. Four of the First Type of Gate Circuit Connected In Cascade.

With the four tubes denoted by V1 - V4 respectively, amplitudes at different points in the chain are tabulated below.

All numbers are amplitude in volts.

Input to V1	Input to V2	Input to V3	Input to V4	Output of V4
7	4	2	0	0
10	8	8	8	8
13	17	20	24	26
15	19	23	25	26

The output of V4 was about 0.07 μs wide in contrast to the 0.1 μs wide input to V1. When the input to V1 was a trapezoidal pulse instead of a round pulse, no significant difference in pulse amplitudes throughout the chain was noted, and the pulse's trapezoidal shape was immediately converted to a round shape.

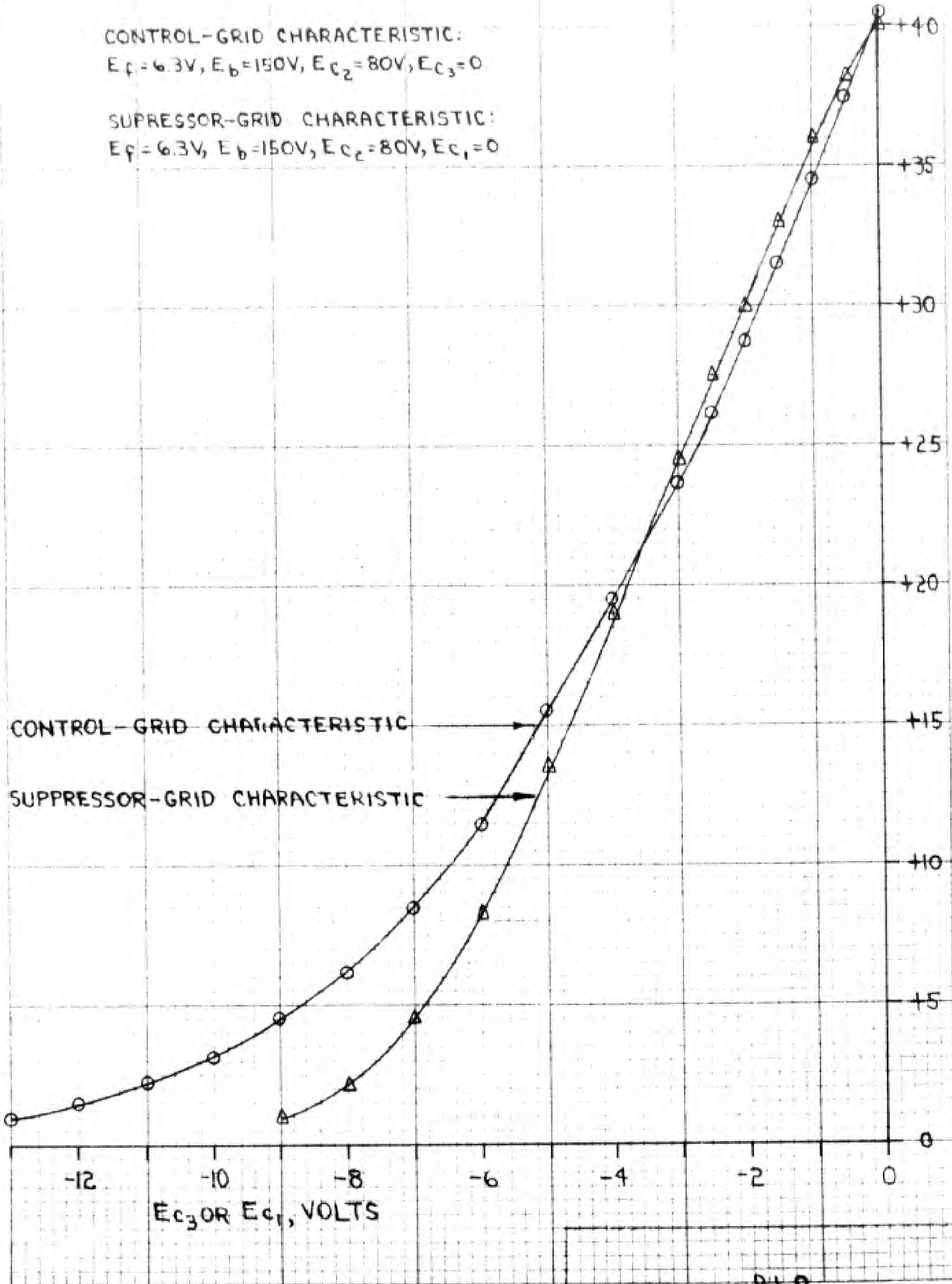
SR-1030 gate tubes of the C-4523 series, when tried in the various circuits above, gave approximately half the output amplitude obtained with gate tubes of the C-4999 series.

Signed Eugene W. Sard
Eugene W. Sard

EWS/sp

Drawing:
A-38302-G

CONTROL-GRID AND SUPPRESSOR-GRID TRANSFER CHARACTERISTICS
TYPE SR-1030, TEST # C-4999, TUBE # 10



A-38302-G-1

6345
B.R.B.
D.L.O.
10-22-47
A-38302-G-1

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: VACUUM TUBE ESTIMATE FOR WWI

To: Jay W. Forrester

From: N. H. Taylor

Date: November 7, 1947

The breakdown of tube quantities in WWI design is as follows:

1. STORAGE — 416
   - Per digit: Storage Tubes 2
   - Amp. & Switch 12
   - Read In & Out 12
   - 26 X 16 digits - 416
2. STORAGE CONTROL — 158
   - 8 Way Switch 31
   - Counter 20
   - Selecting Bank 7
   - Deflection 100
   - 158
3. ARITHMETIC ELEMENT — 896
   - A, B, & Acc Registers 56 X 16 Registers
4. ARITHMETIC ELEMENT CONTROL — 176
5. REGISTER PANEL — 480
   - Check Register, Program Counter, Program Register, & Stepping Register
6. FLIP-FLOP STORAGE — 592
7. TOGGLE SWITCH STORAGE — 341
8. MASTER CLOCK — 40
9. CONTROL — 236
   - Control Switch 111
   - T. P. Distributor 45
   - Operation Matrix 54
   - Program Matrix 26
   - 236
10. GATE DRIVERS & BUFFERS — 160

TOTAL 3495

A breakdown of tubes by functions is estimated below:

Buffer Amplifiers	870
F. F. Tubes	700
Gates	1149
Storage Tubes	32
Indicator Tubes	298
Trigger Tubes	298
Power Tubes	148
Total	3495

N H Taylor
N. H. Taylor

NHT:hcs

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: TUBE TYPES FOR WHIRLWIND I

To: Jay W. Forrester

From: David R. Brown

Date: November 10, 1947

Following is a tabulation of the tube types for Whirlwind I.

a. 2D21

b. 3E29

c. 6AG7

d. 6AK5

e. 6SN7W

f. 6Y6G

g. 7F8

h. 715C

i. SR-1030

a. 2D21

This is a miniature tetrode-type thyration. Tetrode thyrations are needed in the circuits which generate push-button pulses. The 2D21 is adequate for this application; a 2050 would probably work just as well.

b. 3E29

This is a twin-unit beam power amplifier for use as a buffer amplifier. It is used for working into low-impedance loads which demand more current or more power dissipation than is available in the 6AG7. The 3E29 was selected because it is

designed for pulse work and has a steeper transfer characteristic than other tubes in the same power class.

c. 6AG7

This is a power amplifier pentode for use in flip-flop circuits and as a buffer amplifier. It is a metal tube and has an octal base. It was selected for use in these applications because of the steepness of its transfer characteristic and the amount of plate current available. Since Whirlwind I is being designed for maximum accessability and circuits which are coupled together are often far apart in space, shunt capacitances are often determined more by the arrangement of components and the number of components in a load circuit rather than by the tube capacitances themselves. Consequently, the absolute current, rather than the figure of merit, is often the important factor. For this reason, the 6AG7 is superior to the 6AK5 and other low-current, high-transconductance tubes. Its desirability and performance in flip-flop circuits is described in detail elsewhere (vol. 15, R-113, M-56, E-64).

d. 6AK5

This tube is a miniature r-f pentode having a high figure of merit. It may be used in video amplifiers in conjunction with electrostatic storage.

e. 6SN7W

This is an octal-base twin triode. It is a rugged, reliable tube and will be used to operate the indicator lights which indicate flip-flop orientation.

f. 6Y6G

This is a beam-type power amplifier for use as a buffer amplifier. It provides greater plate current than the 6AG7 at the same screen and plate voltages but requires a greater grid swing. Where the grid-swing is available, it may be used to advantage instead of the 6AG7.

g. 7F8

This is a loctal-base twin triode having high transconductance. It may be used with the 32-position switch to improve the switching time. An effort will be made to use the 6SN7W for this application.

h. 715C

This is pulse-amplifier tetrode in the transmitting class. It is used as an amplifier in the electrostatic deflection circuits which must work into a 100-ohm load. It was selected because it has sufficient transconductance to give a gain greater than unity while working into this load. It has a higher transconductance than any other tube in the same power class. Also, it does not require special cooling.

SR-1030

This is the Sylvania-type number for a gate tube which has been developed by Sylvania for Project Whirlwind. The reasons for the use of a special tube are discussed in volume 16.

David R. Brown

David R. Brown

5366
Report No. R-147

SERVOMECHANISMS LABORATORY
Massachusetts Institute of Technology
Cambridge, Massachusetts

Date of Report: April 1, 1947

Written by: Ray L. Ellis

Subject: Characteristics of Littlefuse, No. 21107, and General Electric NE-51, Neon Lamps.

References: 3SLE146-152
3SLE2-4

Drawings:
A-30466
A-38178-3
A-38179-3
A-38180-3
A-38181-3
A-38182-3
A-38183-3

Summary:

Striking voltages for ten Littlefuse, 211007, neon lamps were measured and found to range from 65 volts to 84 volts; average 72 volts. The holding voltages, extinction of glow, were measured and found to range from 49 volts to 62 volts; average 53 volts. The first striking voltage is sometimes higher than succeeding striking voltages. Reducing ambient temperature of lamps increased the striking voltage. Changing the polarity of Littlefuse lamps caused the striking voltage to change as much as 10 volts.

Striking voltages for ten General Electric, NE-51, neon lamps were measured and found to range from 62 volts to 88 volts; average 69 volts. Holding voltages were measured and found to range from 45 volts to 50 volts; average 50 volts. The difference between first striking voltages and succeeding ones did not exceed one volt. Reversing polarity of NE-51 lamps changed the striking voltage less than one volt.

Method of Obtaining Characteristics:

Ten lamps of each type were chosen at random to study the striking and holding voltages. A 100,000-ohm resistor was put in series with the lamp under test and voltage measured across the lamp with a vacuum-tube voltmeter having an input resistance greater than 10 megohms. A microammeter was placed in series with the 100,000-ohm resistor. The circuit diagram is shown in Drawing A-30466. Data were obtained to show the relation of current to voltage. Applied voltage was increased and current measured. Readings were taken at and just after striking. Voltage readings were also taken at 200, 400, 600, 800, and 1000 microamperes. The applied voltage was reduced and the voltage readings again taken at the above current values to make certain the curve retraced itself. Readings were also taken at 100 and 50 microamperes as well as just before and after extinction of glow.

The relation of current to voltage is shown for three of the

[illegible] Littlefuse lamps by Drawings A-33181-G, A-33182-G, and A-33183-G. Those for three of the ten General Electric lamps are shown by Drawings A-33178-G, A-33179-G, and A-33180-G. The curves for the three Little-fuse lamps are flat and have a rise of 5 volts for 1000 microamperes. This would make them good for voltage regulation. The curves for three General Electric Lamps are less flat and have a rise of 9.5 volts for 1000 microamperes.

Technician:

Engineer: David R. Brown

Approved:

RL:has

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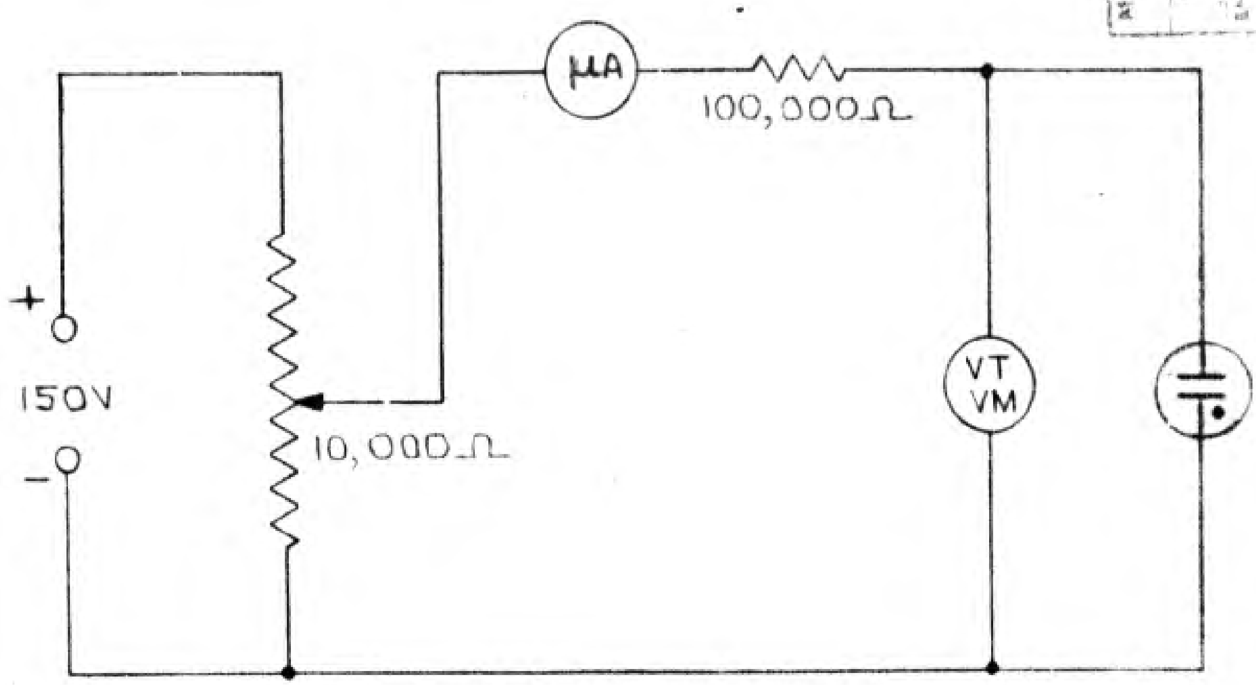
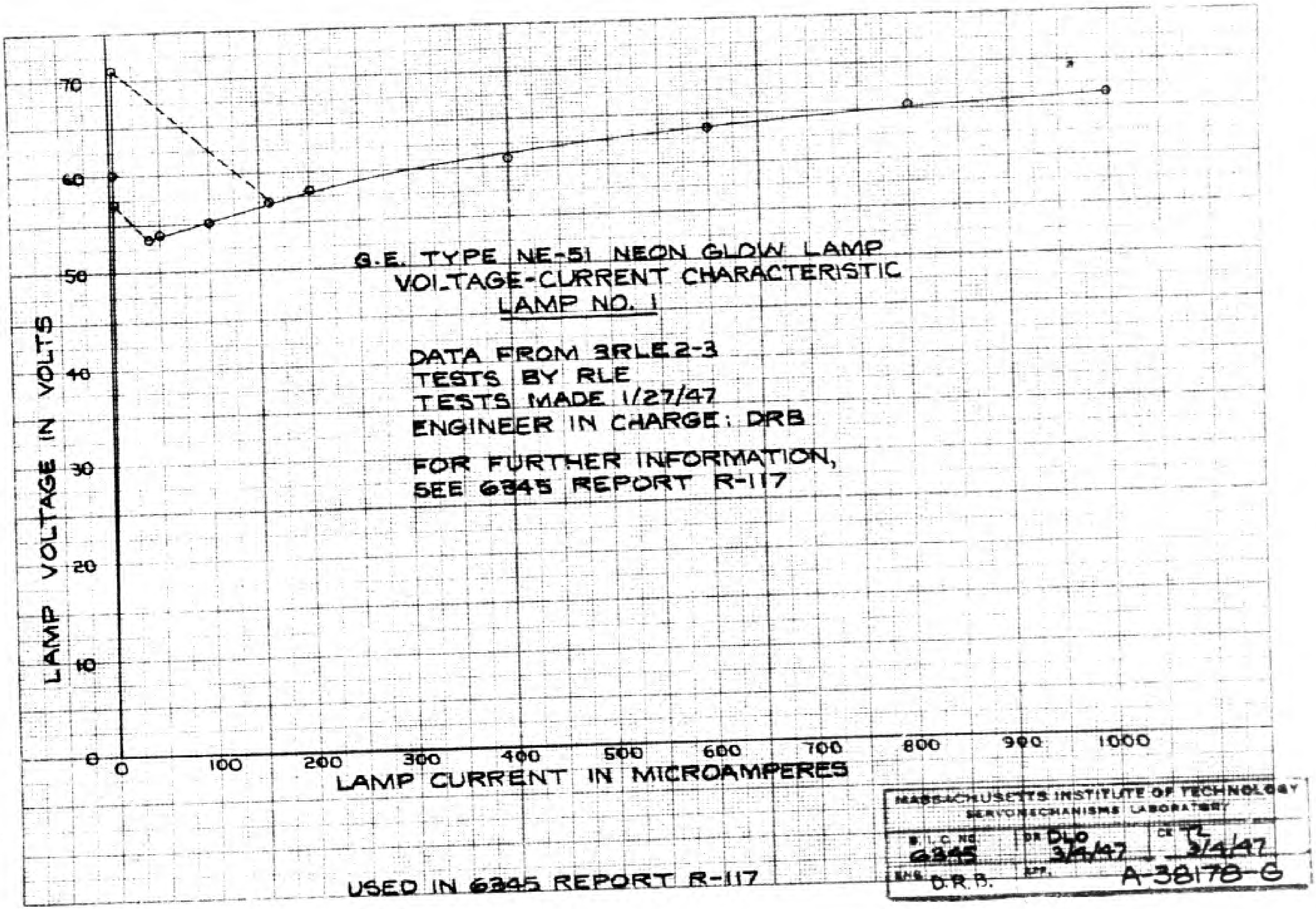
SERVOMECHANISMS LABORATORY

P.I.C. NO. 6395 | DR. DLO 9/11/47 | CK. TL 9/14/47
ENG. D.R.B. | APP. | A-30466



TEST CIRCUIT FOR NEON LAMPS

A-30466


G.E. TYPE NE-51 NEON GLOW LAMP
VOLTAGE-CURRENT CHARACTERISTIC
LAMP NO. 1
DATA FROM 3RLE 2-3
TESTS BY RLE
TESTS MADE 1/27/47
ENGINEER IN CHARGE: DRB
FOR FURTHER INFORMATION,
SEE 6345 REPORT R-117
LAMP VOLTAGE IN VOLTS
0
10
20
30
40
50
60
70
0
100
200
300
400
500
600
700
800
900
1000
LAMP CURRENT IN MICROAMPERES
USED IN 6345 REPORT R-117
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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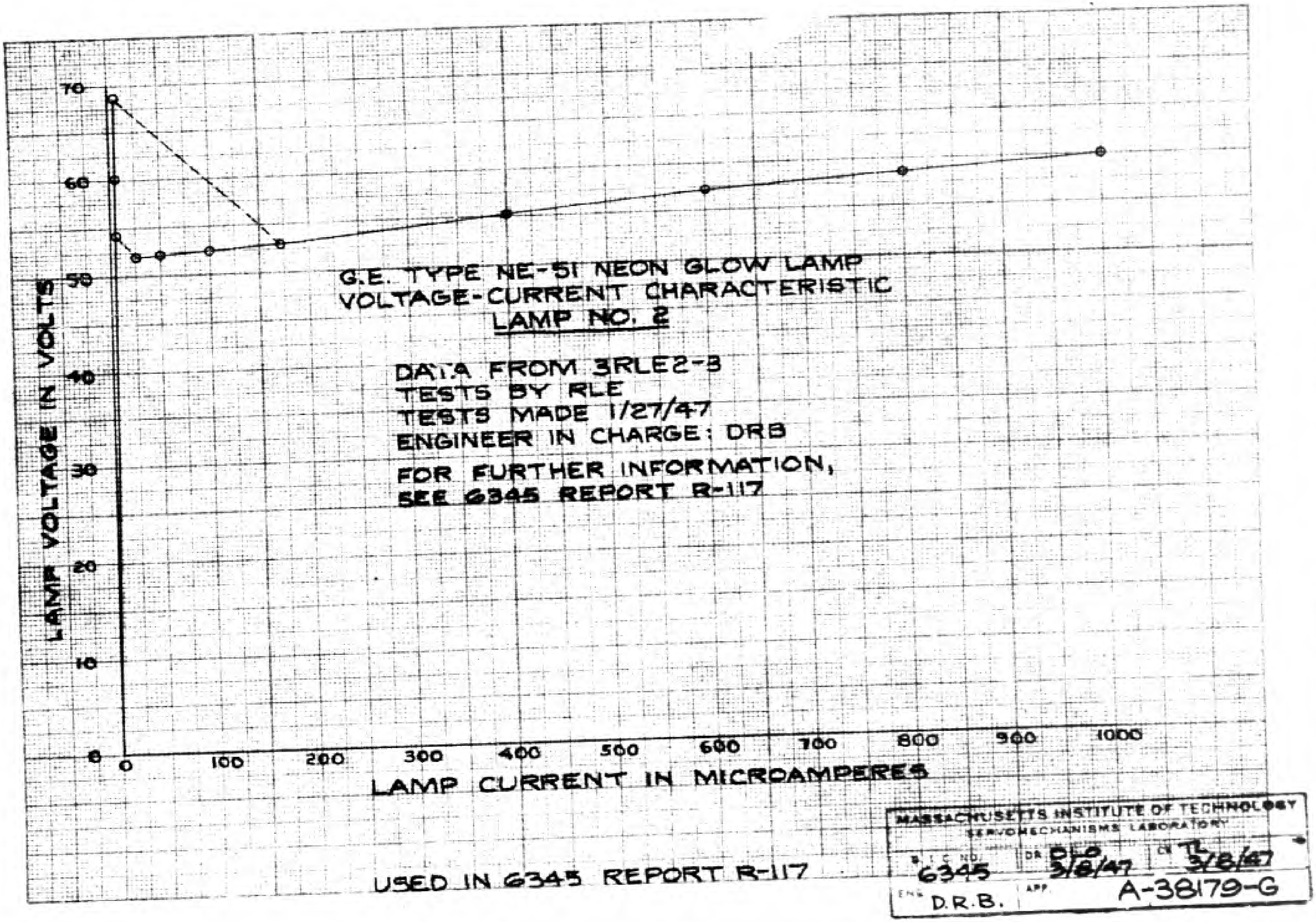
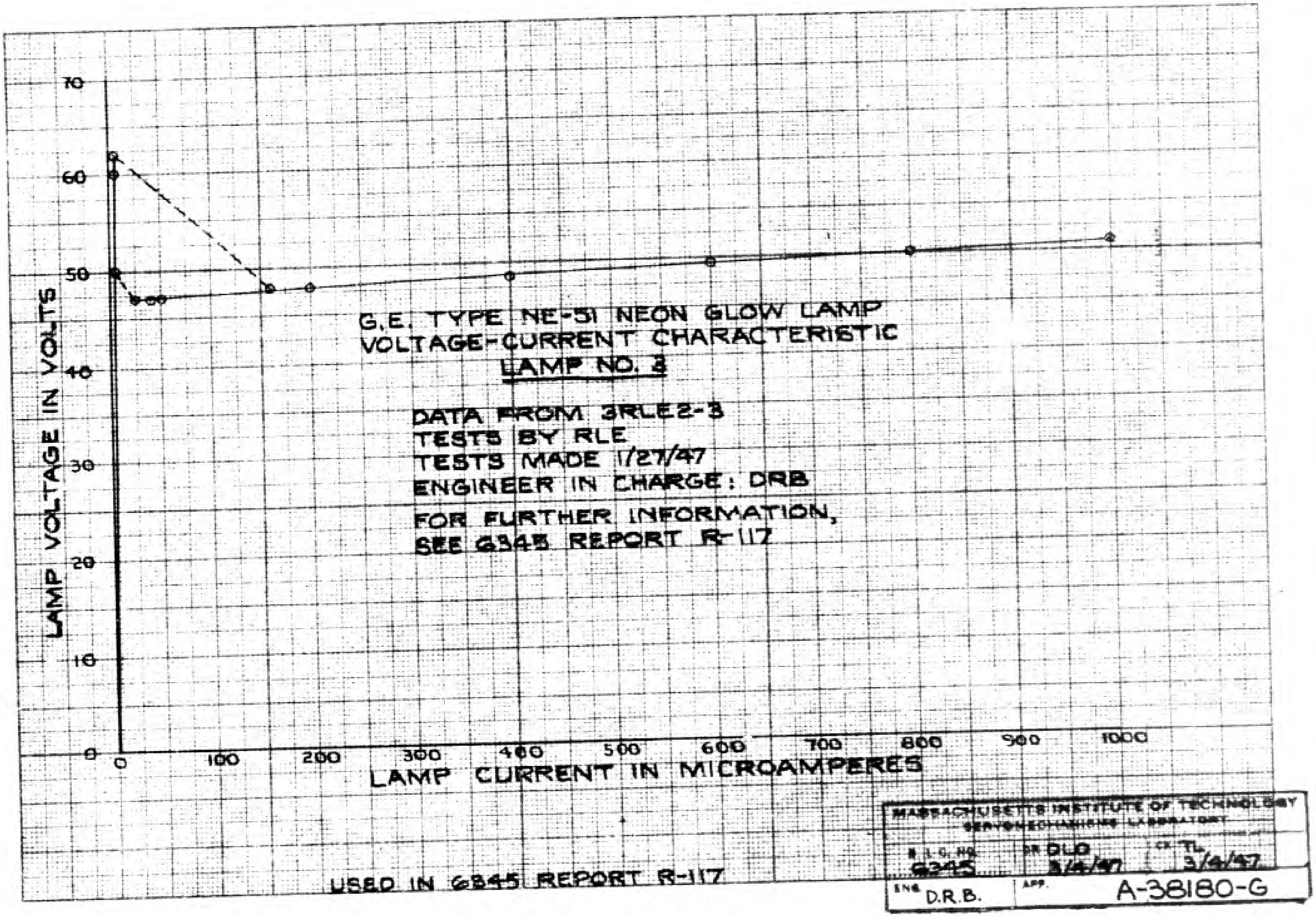
6345
DLO 3/4/47
3/4/47
D.R.B.
A-38178-G


G.E. TYPE NE-51 NEON GLOW LAMP
VOLTAGE-CURRENT CHARACTERISTIC
LAMP NO. 2
DATA FROM 3RLE2-3
TESTS BY RLE
TESTS MADE 1/27/47
ENGINEER IN CHARGE: DRB
FOR FURTHER INFORMATION,
SEE 6345 REPORT R-117
LAMP VOLTAGE IN VOLTS
0
10
20
30
40
50
60
70
LAMP CURRENT IN MICROAMPERES
0
100
200
300
400
500
600
700
800
900
1000
USED IN 6345 REPORT R-117
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY
6345
DLO 3/8/47
TL 3/8/47
D.R.B.
A-38179-G



G.E. TYPE NE-51 NEON GLOW LAMP
VOLTAGE-CURRENT CHARACTERISTIC
LAMP NO. 3
DATA FROM 3RLE2-3
TESTS BY RLE
TESTS MADE 1/27/47
ENGINEER IN CHARGE: DRB
FOR FURTHER INFORMATION,
SEE 6345 REPORT R-117
LAMP VOLTAGE IN VOLTS
0
10
20
30
40
50
60
70
LAMP CURRENT IN MICROAMPERES
0
100
200
300
400
500
600
700
800
900
1000
USED IN 6345 REPORT R-117
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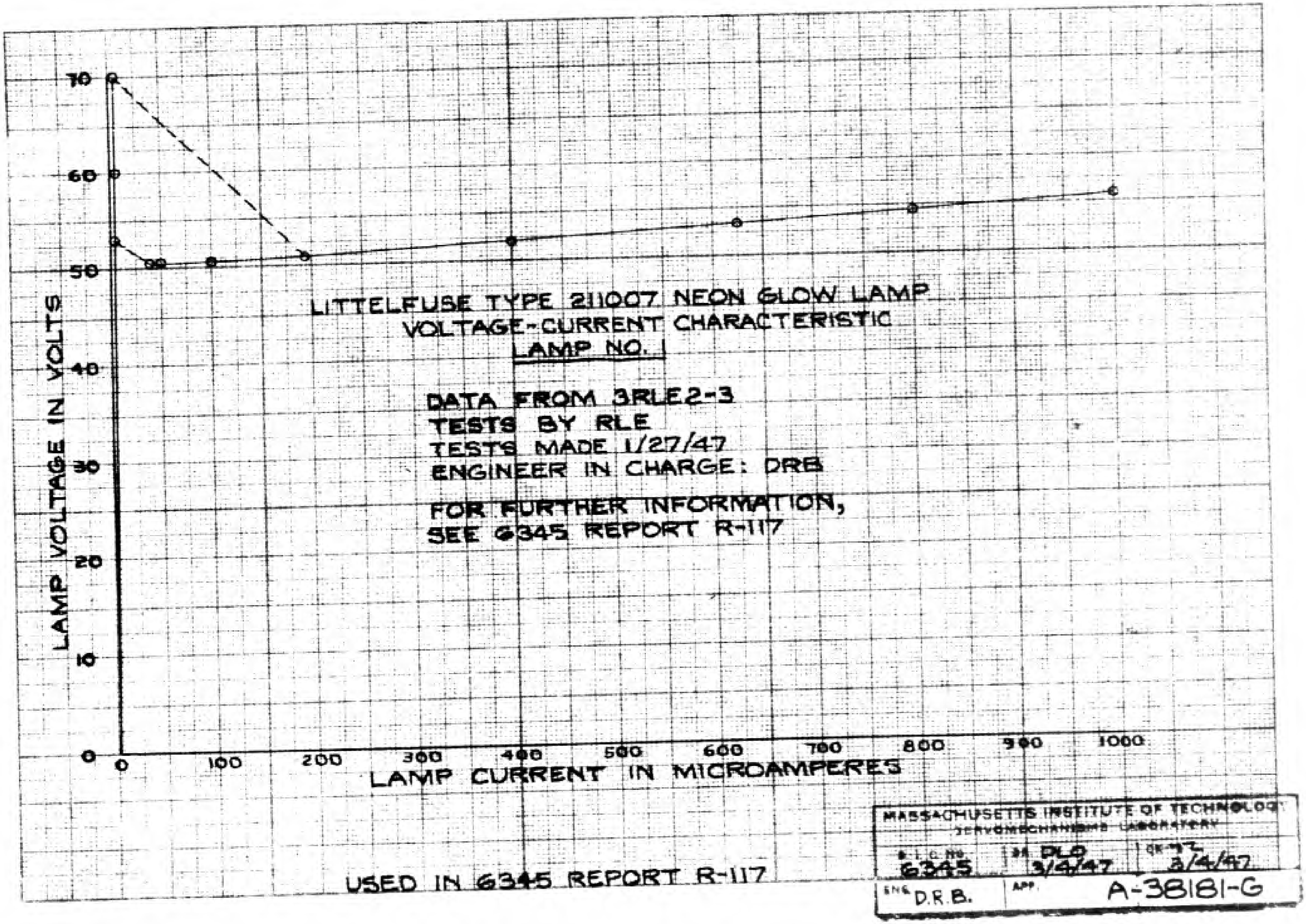
D.I.C. NO. 6345
DR DLO 3/4/47
CK TL 3/4/47
ENG D.R.B.
APP.
A-38180-G


LITTELFUSE TYPE 211007 NEON GLOW LAMP
VOLTAGE-CURRENT CHARACTERISTIC
LAMP NO. 1
DATA FROM 3RLE2-3
TESTS BY RLE
TESTS MADE 1/27/47
ENGINEER IN CHARGE: DRB
FOR FURTHER INFORMATION,
SEE 6345 REPORT R-117
LAMP VOLTAGE IN VOLTS
0
10
20
30
40
50
60
70
0
100
200
300
400
500
600
700
800
900
1000
LAMP CURRENT IN MICROAMPERES
USED IN 6345 REPORT R-117
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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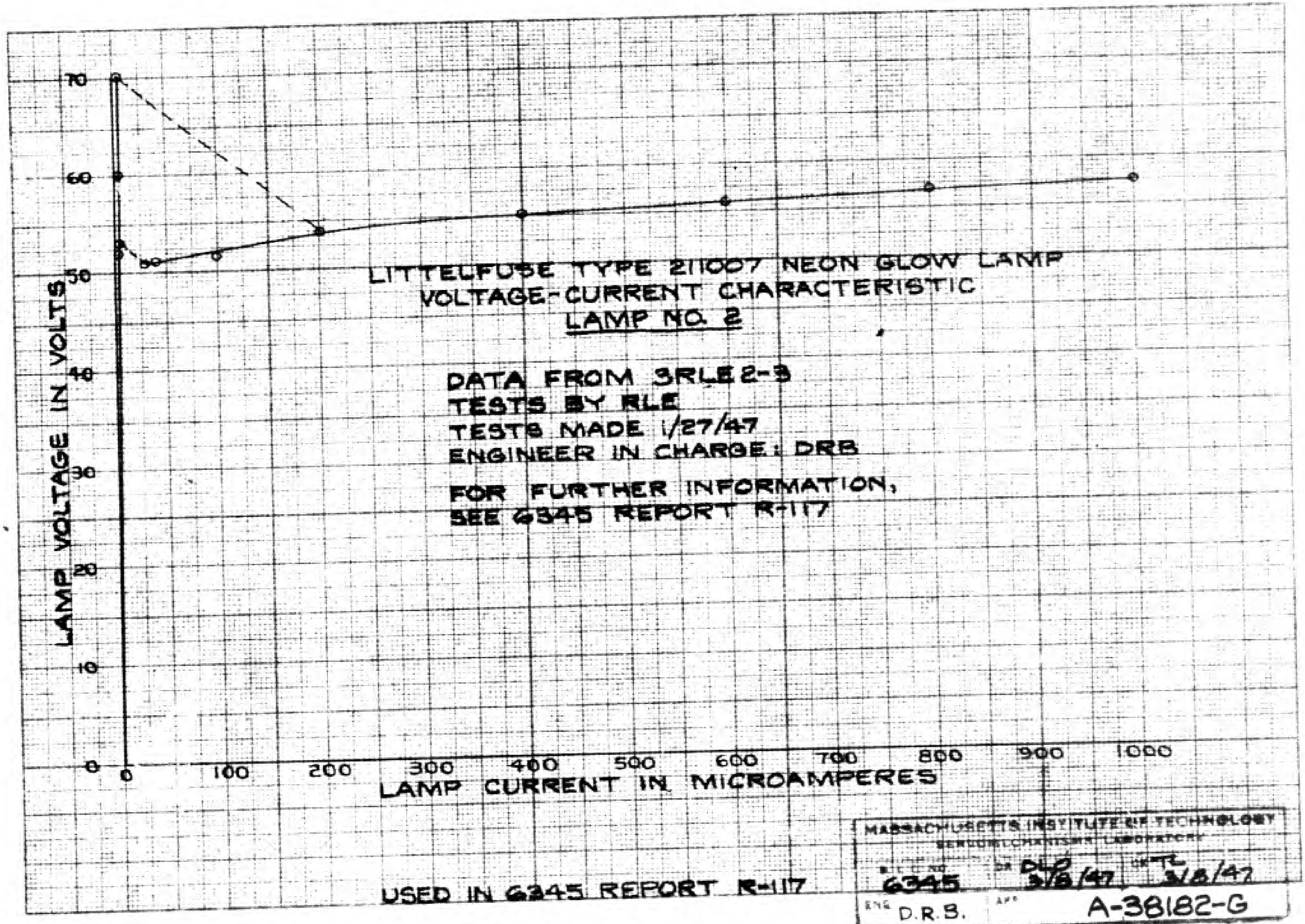
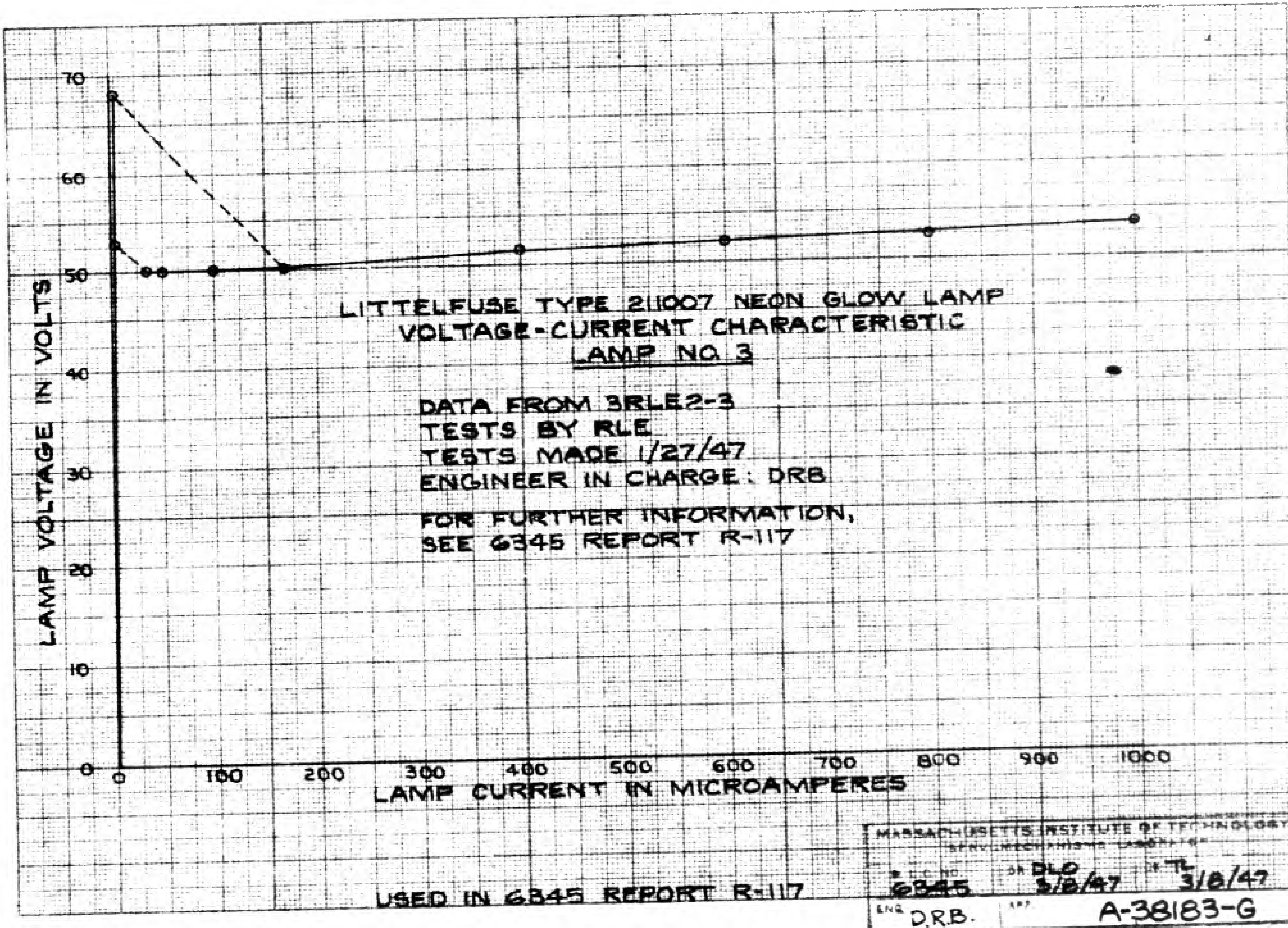
6345
DLO
3/4/47
3/4/47
ENG. D.R.B.
APP.
A-38181-G



LITTELFUSE TYPE 211007 NEON GLOW LAMP
VOLTAGE-CURRENT CHARACTERISTIC
LAMP NO. 2
DATA FROM 3RLE 2-3
TESTS BY RLE
TESTS MADE 1/27/47
ENGINEER IN CHARGE: DRB
FOR FURTHER INFORMATION,
SEE 6345 REPORT R-117
LAMP VOLTAGE IN VOLTS
0
10
20
30
40
50
60
70
0
100
200
300
400
500
600
700
800
900
1000
LAMP CURRENT IN MICROAMPERES
USED IN 6345 REPORT R-117
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
6345
DLO 3/8/47
3/8/47
D.R.B.
A-38182-G


LITTELFUSE TYPE 211007 NEON GLOW LAMP
VOLTAGE-CURRENT CHARACTERISTIC
LAMP NO. 3
DATA FROM 3RLE2-3
TESTS BY RLE
TESTS MADE 1/27/47
ENGINEER IN CHARGE: DRB
FOR FURTHER INFORMATION,
SEE 6345 REPORT R-117
LAMP VOLTAGE IN VOLTS
0
10
20
30
40
50
60
70
LAMP CURRENT IN MICROAMPERES
0
100
200
300
400
500
600
700
800
900
1000
USED IN 6345 REPORT R-117
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
6345
DLO 3/8/47
3/8/47
D.R.B.
A-38183-G

MEMORANDUM NO. M-72

SERVOMECHANISMS LABORATORY
Massachusetts Institute of Technology
Cambridge, Massachusetts

TO:	Jay W. Forrester, S. H. Dodd, W. Nolan J.R. Macdonald, P. Youtz	6345 Page 1 of 2 pages
FROM:	Russell Palmiter	Drawings: SA-38198-G
SUBJECT:	Deionization Characteristics of General Electric NE-2 Neon Lamp.	SA-38199-G SA-38200-G SA-39201-G
DATE:	April 29, 1947	SA-39202-G

Purpose - The purpose of this test was to obtain preliminary information on the deionization time of a glow discharge.

Procedure - The General Electric NE-2 Neon Lamp was chosen for this preliminary test because of its availability and convenient size.

The circuit used is shown in Drawing SA-39202. Resistors R_1 and R_2 provide a variable ionizing voltage measured with the Voltohmyst at V. Switches S_1 and S_2 permit ionizing or deionizing the lamp without disturbing the setting of potentiometer R_2.

R_3 serves as a current limiting resistor for the lamp, and also isolates the pulse from the low resistance potentiometer circuit. R_4 provides at S_1 a voltage output proportional to lamp current for scope presentation.

A positive pulse is applied at J_2 through an output condenser in the pulse amplifier. The 1N34 and C_2 were added to remove a negative overshoot on the pulse, and C_1 and R_5 corrected a drooping pulse characteristic on the longer pulse durations. Pulse amplitude was measured on the synchroscope.

The deionization characteristic was obtained by setting R_2 to obtain a negative holding potential, or bias, greater than the deionizing voltage but less than the ionizing potential. The minimum pulse width required to consistently extinguish the lamp at various positive pulse amplitudes was recorded.

Results - These data are plotted for three lamps in Drawings SA-38198-G through SA-38200-G. For each lamp, curves are shown for three bias voltages within the limits noted above.

It should be noted that the curves are titled "Pulse Amplitude vs. Pulse Width Required to Deionize at Constant Holding Voltages", in strict accordance with the test procedure. Subsequent observation of

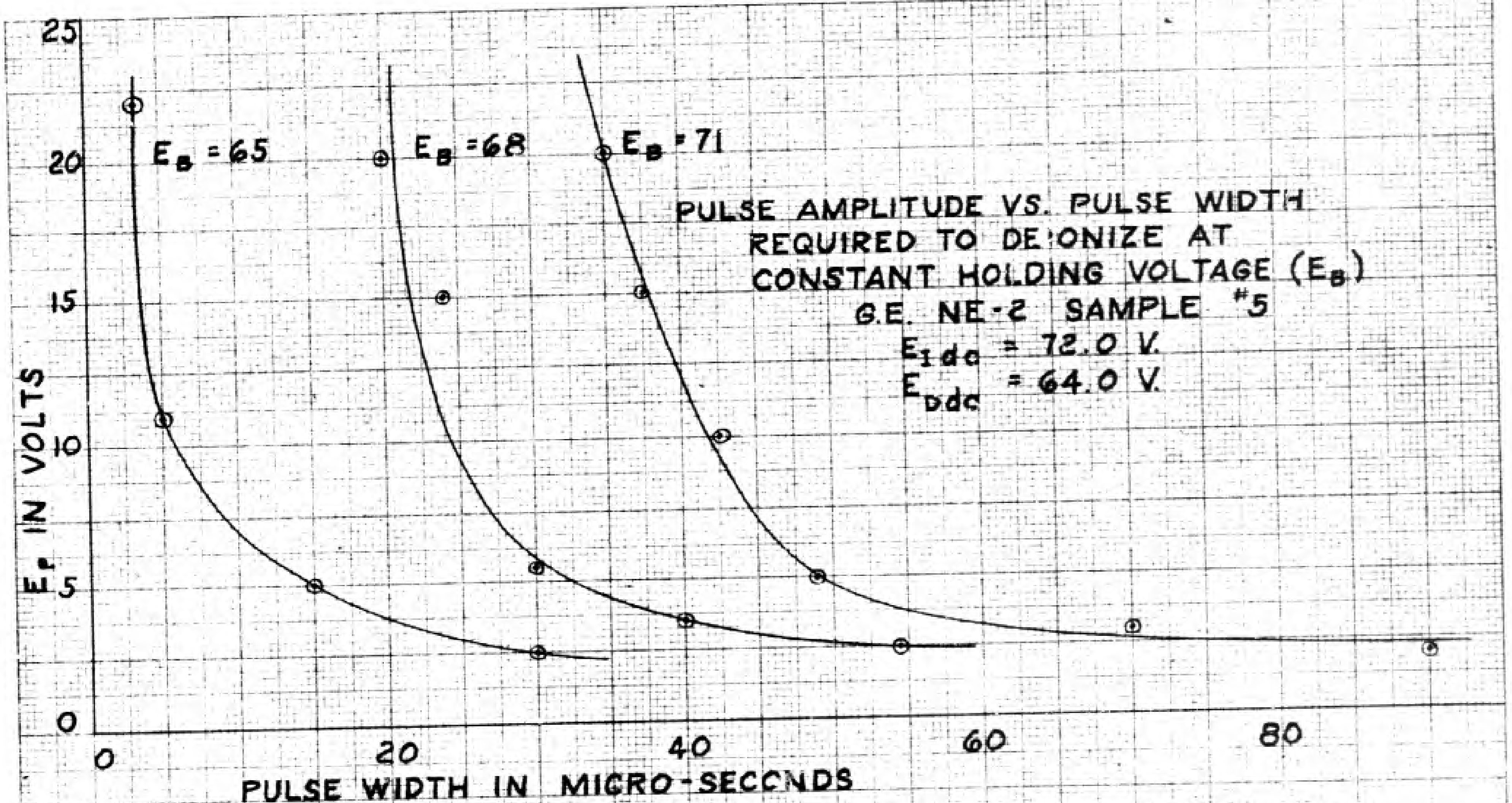
lamp current with constant bias and pulse amplitude but with a variable pulse width indicates that these data may be considered to be Pulse Amplitude vs. Deionization Time at Constant Holding Voltage. With a pulse too short to extinguish the lamp, the lamp current did not fall to zero. Pulse widths equal to or greater than the value required to extinguish the lamp gave a constant time of fall for lamp current. Spot checks made in this manner agree with plotted data within the limits of precision of the test procedure.

It was noticed that pulse amplitudes greater than the maximum values shown necessitated increasing pulse duration to extinguish the lamp. It is believed that this was due to deficiencies in the test equipment. In this region of the characteristics a high rate of change obtains, and slight departure of the pulse shape from true rectangular is offered as a possible explanation of this phenomenon.

Conversely, the low rate of change at the other end of the characteristic indicates that, if desired, much longer time intervals could be observed with smaller pulse amplitudes and increments.

Russell B Palmiter
Russell Palmiter

RP:has



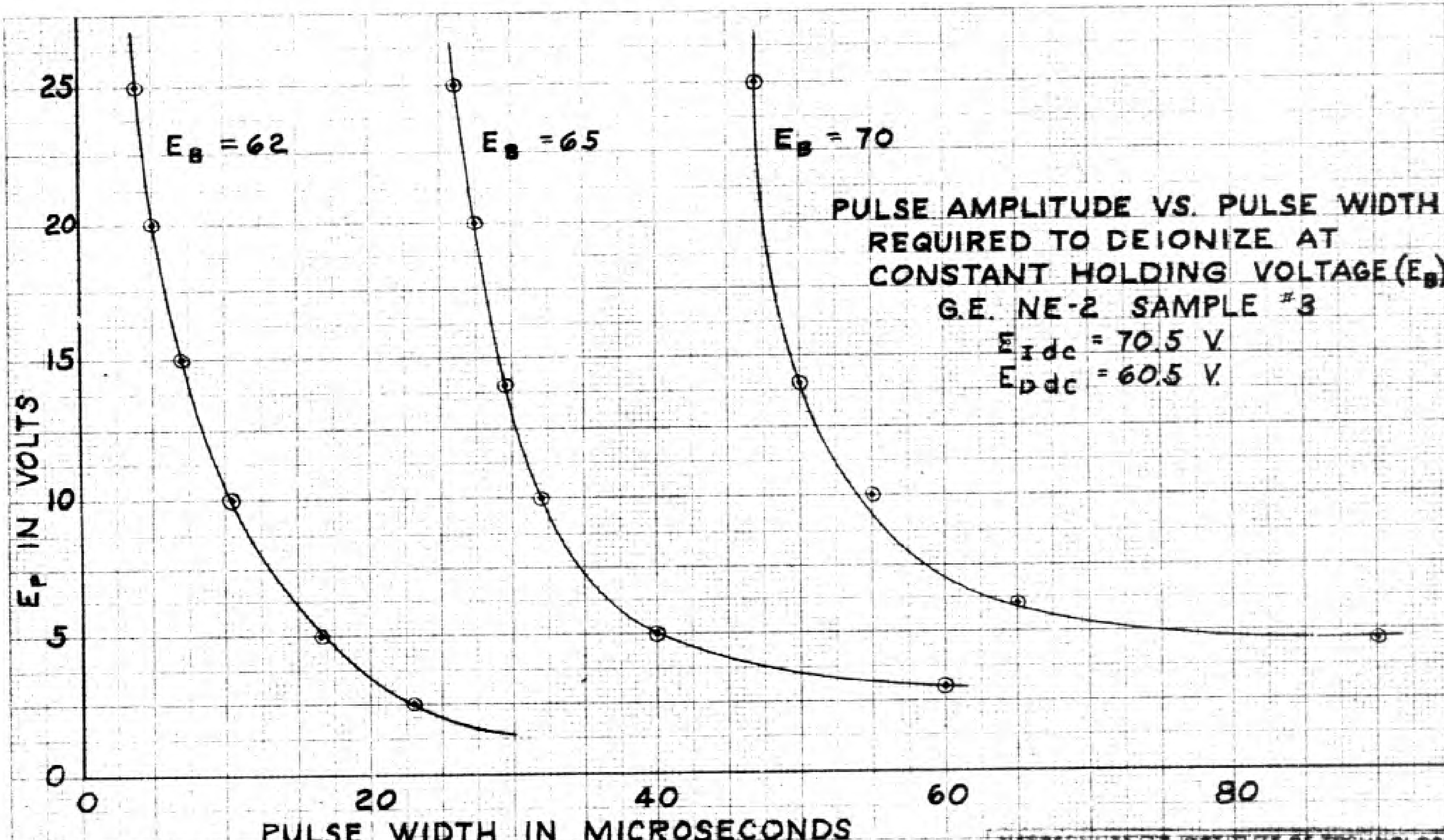
PULSE AMPLITUDE VS. PULSE WIDTH
REQUIRED TO DE-IONIZE AT
CONSTANT HOLDING VOLTAGE (E_B)
G.E. NE-2 SAMPLE #5
E_{Idc} = 72.0 V.
E_{Ddc} = 64.0 V.

DATA FROM 1RBP34
TESTED BY RBP DATE 4/22/47
ENGINEER IN CHARGE JWF

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SERVOMECHANISMS LABORATORY

D.I.C. NO. 6345 | DATE 4/25/47 | BY RBP
| NO. SA-38198-G

FORM I.T. TECHNOLOGY STORE, H. C. S. 40 MASS. AVE., CAMBRIDGE, MASS.



DATA FROM IRBP34
TESTS BY RBP DATE 4/22/47
ENGINEER IN CHARGE JWF

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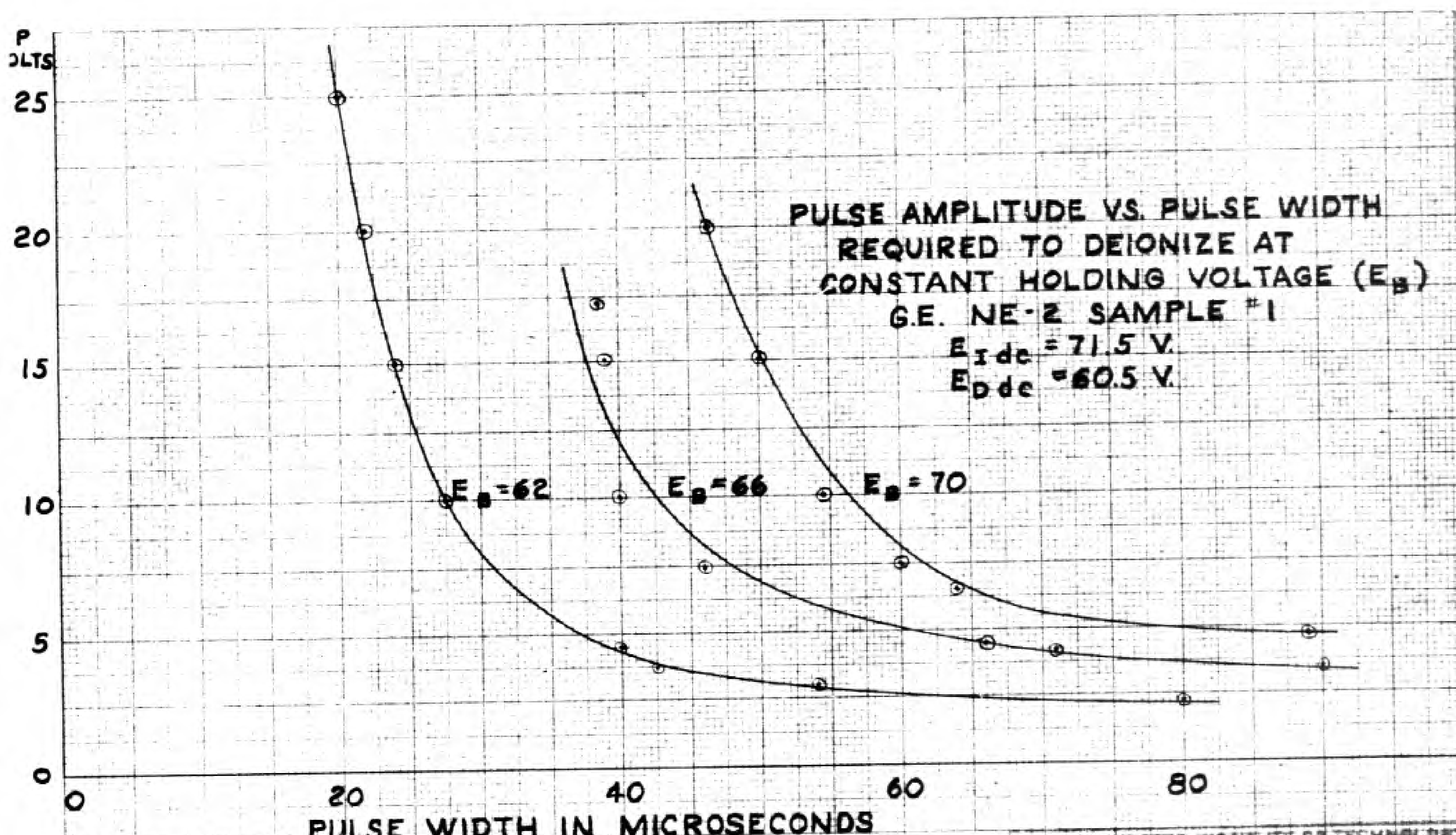
SERVOMECHANISMS LABORATORY
6345 WJC 4/24/47 RBP
SA-38199-G

FORM I T TECHNOLOGY STORE, H. C. S. 40 MASS. AVE. CAMBRIDGE, MASS.



DATA FROM LRBP34

TESTS BY RBP DATE 4/22/47

ENGINEER IN CHARGE JWF

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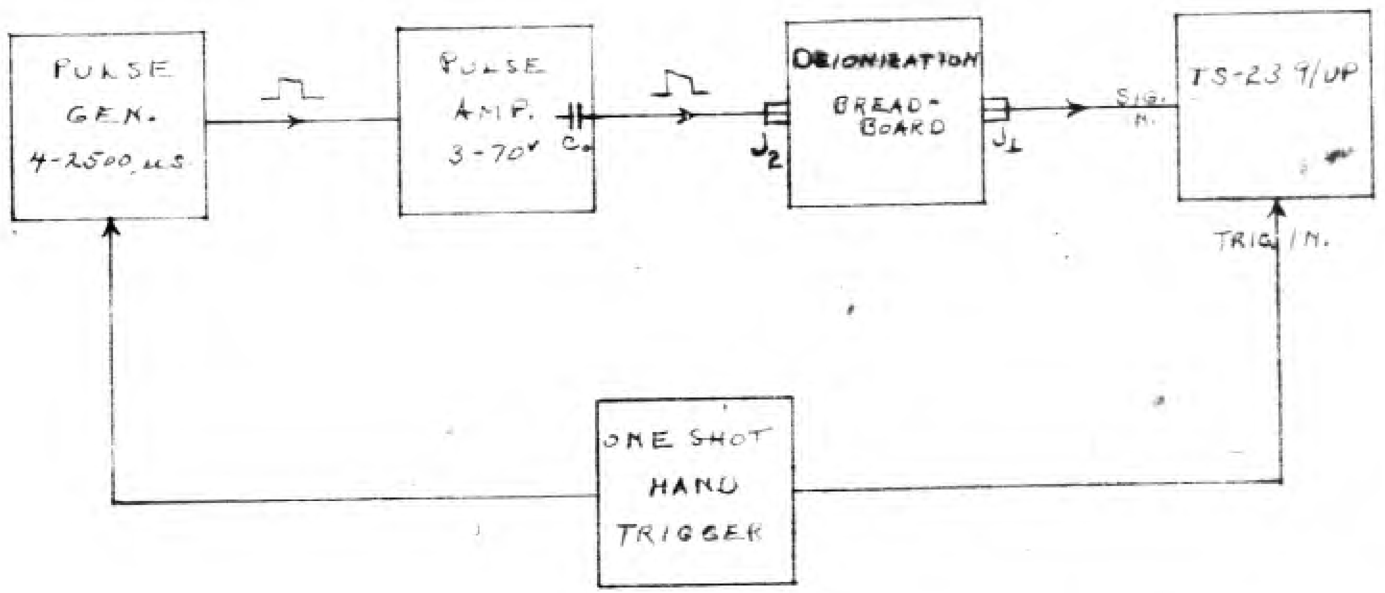
SERVOMECHANISMS LABORATORY

6345 WJC 4/24/47 RBP

SA-38200-G

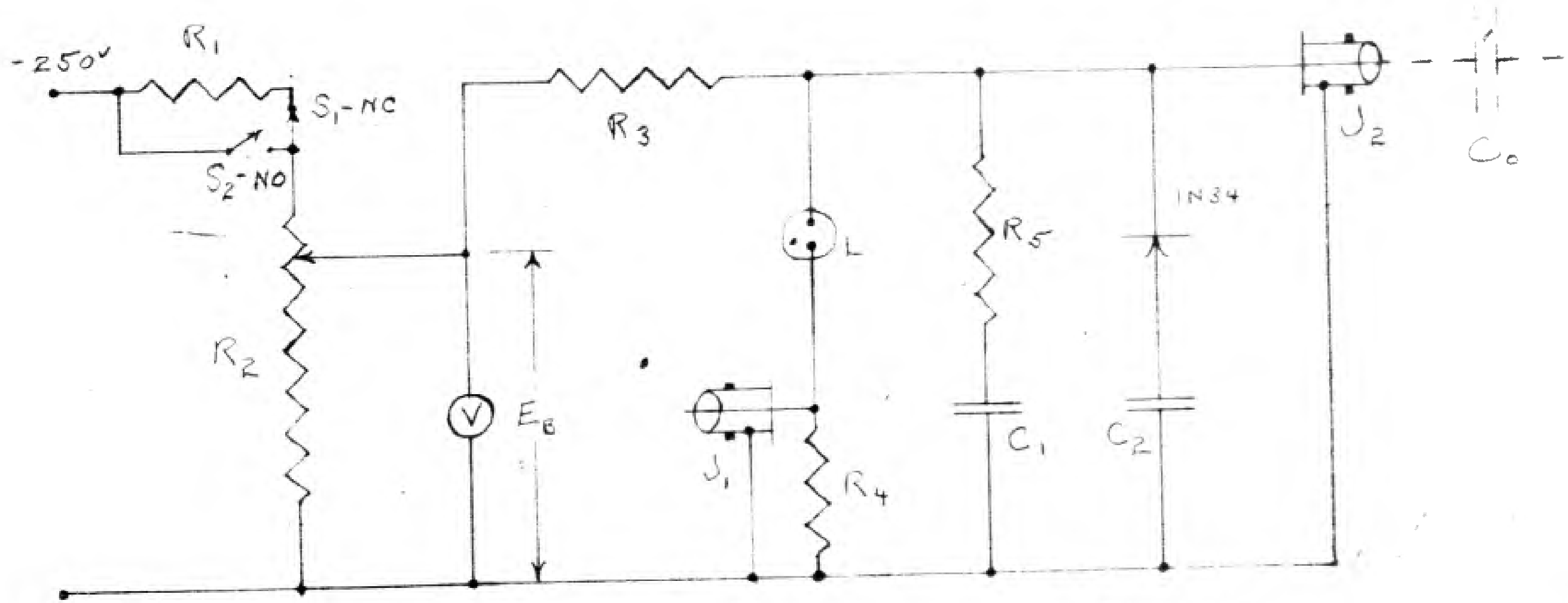
SA-39201



BLOCK DIAGRAM - DEIONIZATION TESTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY SERVOMECHANISMS LABORATORY		
D.I.C. NO. 6345	DR R.B.P. 5/1/47	CK
ENG	APP	SA-39201

SA-39202



V- VOLTOHMYST (CM660)
L- G.E. NE-2
J_1- LAMP CURRENT OUTPUT
J_2- SQ. WV. INPUT

R_1, R_4 - 10,000 Ω
R_2 - 15,000 Ω
R_3, R_5 - 100,000 Ω
C_1, C_2 - 0.1 μfd

C_0-PULSE AMPLIFIER OUTPUT CONDENSER

DEIONIZATION BREADBOARD

MASSACHUSETTS INSTITUTE OF TECHNOLOGY SERVOMECHANISMS LABORATORY		
B.L.C. NO. 6345	DR R.B.P. 5/1/47	CH
ENG.	APP.	SA-39202

63[illegible]
Report No. R-118

SERVOMECHANISMS LABORATORY
Massachusetts Institute of Technology
Cambridge, Massachusetts

Date of Report: February 18, 1947

Written by: C. W. LeBlanc

Subject: Static Characteristics of RCA 6AG7 Vacuum Tubes.

Drawings:
B-38175-G
B-38176-G
B-38177-G

Purpose of Test: To supplement published data.

Reference: Data found in 1CWL 5-19.

Conclusions: With screen voltages of 50 volts, two of the six tubes tested showed a random low-frequency drift which varied I_{c_2} and I_p as much as 1.2 milliamperes each. Control grid current was too small to give a measurable indication on a one milliampere meter when the control grid was more than one-half volt negative. Maximum control grid current at + 1 volt E_{c_1} for the six tubes tested was 2.5 milliamperes with values of E_{c_2} at + 50, + 100, + 150 volts.

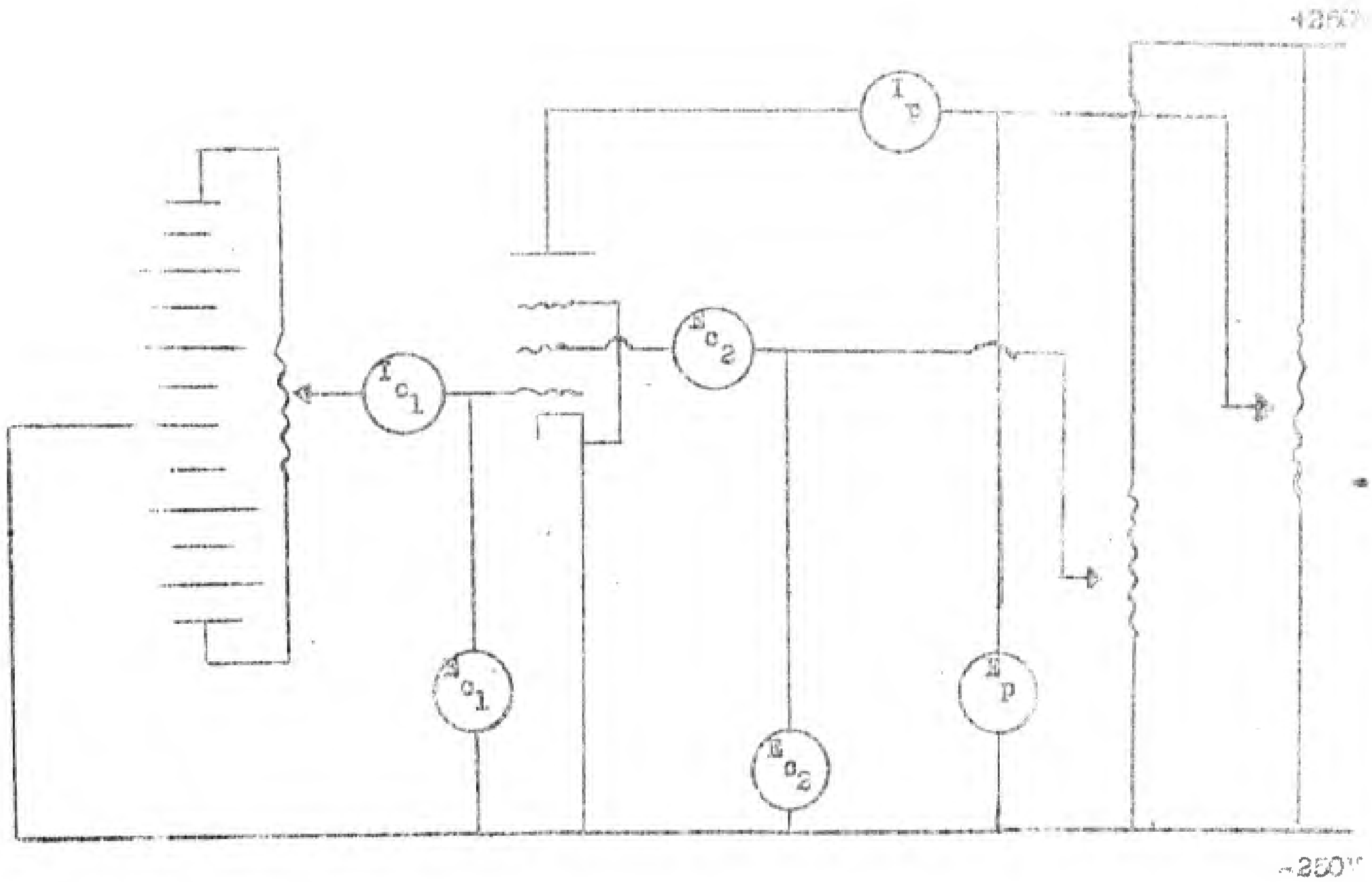
When E_{c_1} is more than 2 volts negative at + 50 volts E_{c_2}, I_p and I_{c_2} become quite small and were not plotted. This holds true for values of E_{c_1} greater than -5 volts when E_{c_2} = 100 volts, and values greater than -7 volts when E_{c_2} = 150 volts.

Technician: C. W. LeBlanc

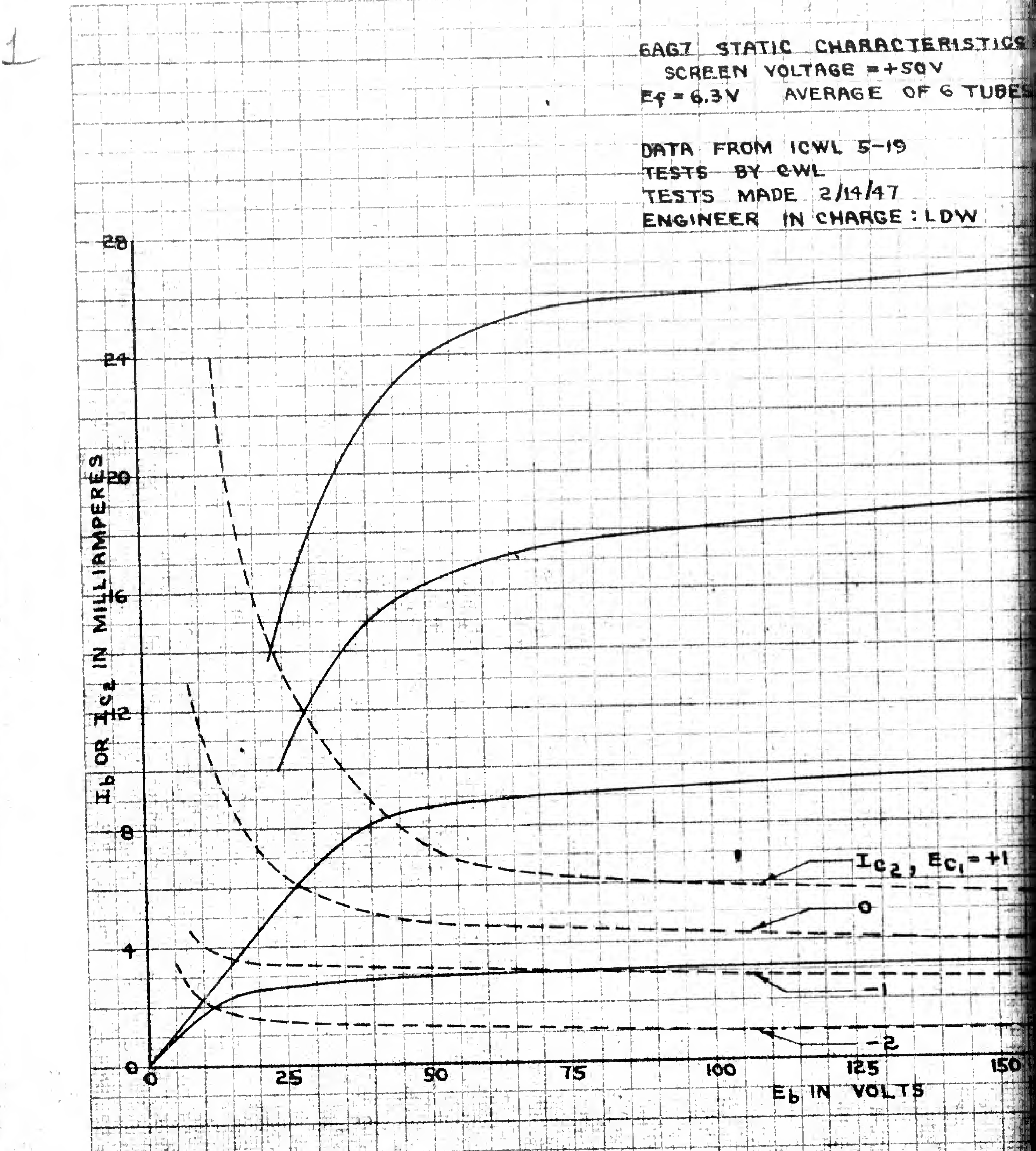
Engineer: Louis D. Wilson

Approved:

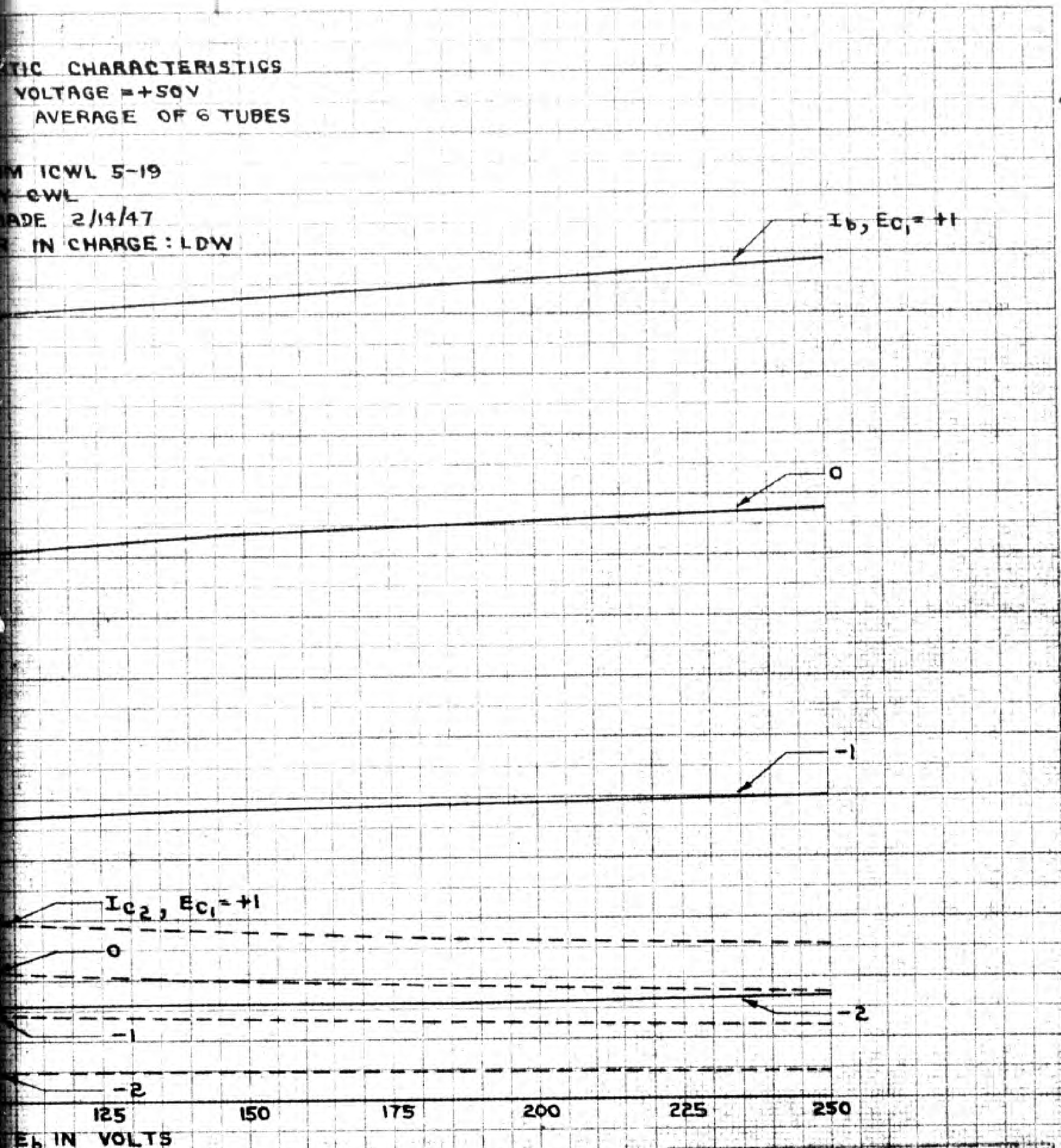
LDW:hav



CIRCUIT DIAGRAM OF EQUIPMENT USED FOR TEST



1
6AG7 STATIC CHARACTERISTICS
SCREEN VOLTAGE = +50V
Ef = 6.3V AVERAGE OF 6 TUBES
DATA FROM ICWL 5-19
TESTS BY CWL
TESTS MADE 2/14/47
ENGINEER IN CHARGE: LDW
Ib OR Ic2 IN MILLIAMPERES
Eb IN VOLTS
Ic2, Ec1 = +1
0
-1
-2
0
4
8
12
16
20
24
28
0
25
50
75
100
125
150
USED



USED IN 6345 REPORT R-118

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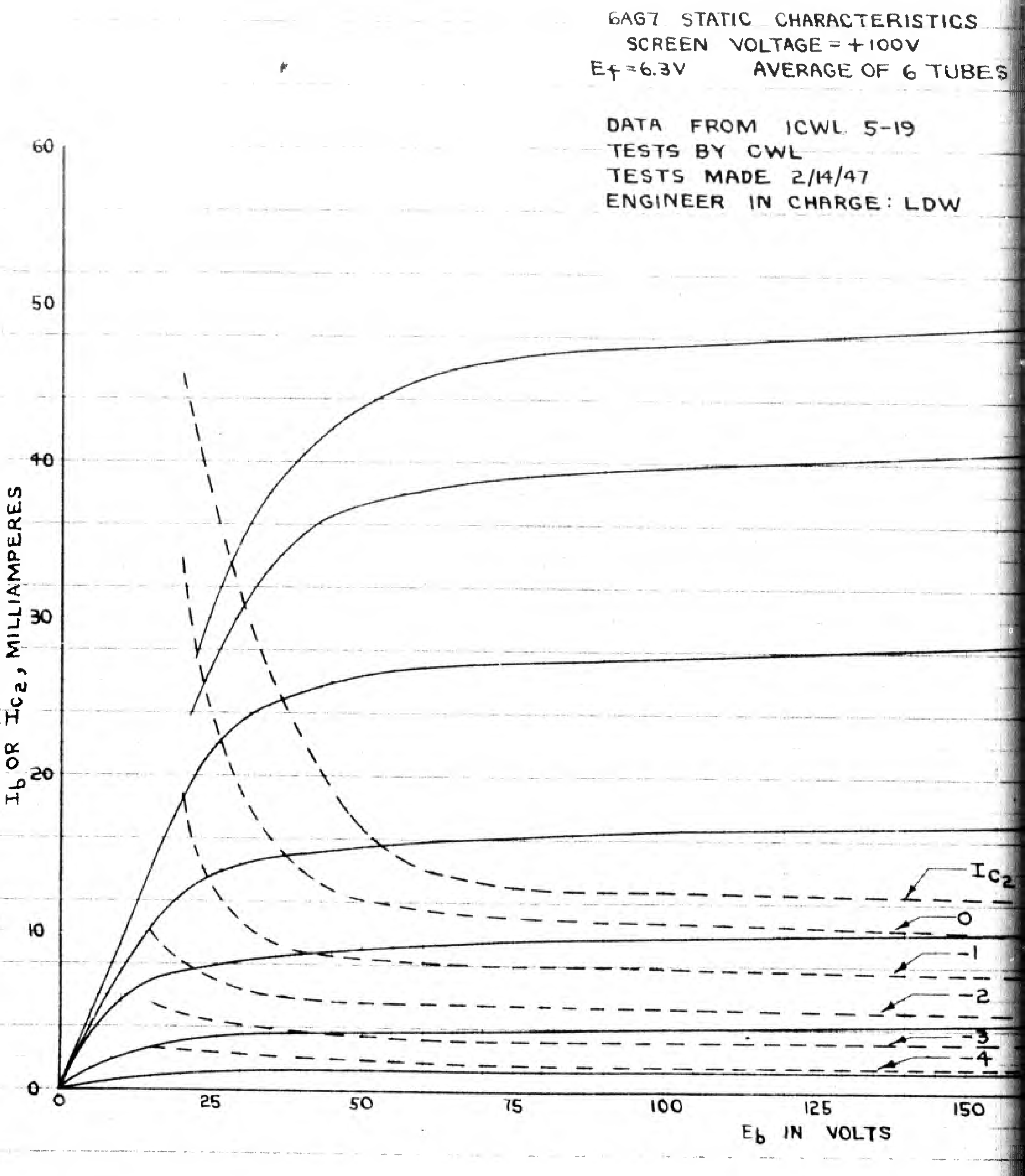
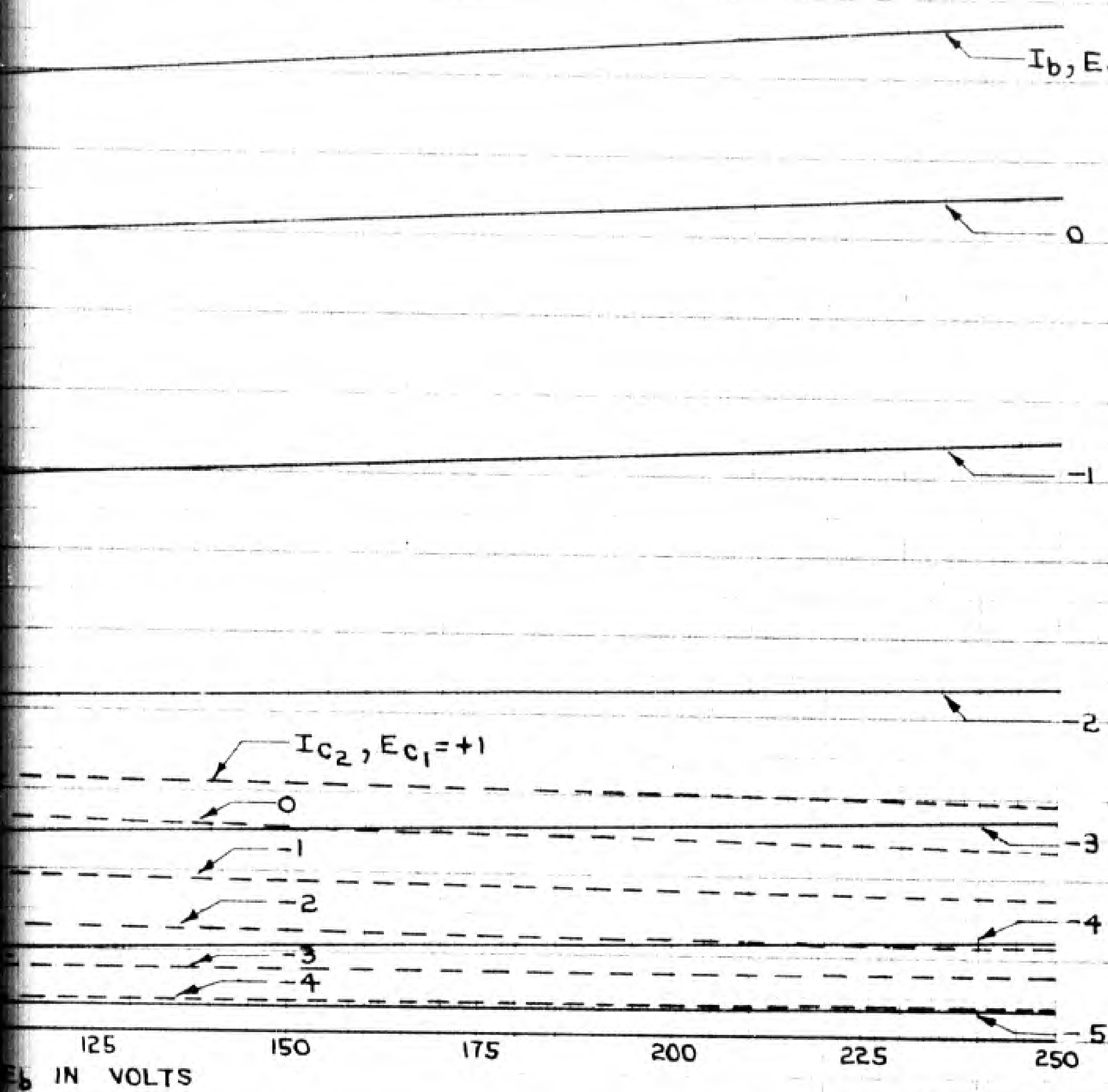
D.L.C. NO. | DR. D.L.C. 2-27-47 | CK. 3/1/47
ENG. LDW | APP. | B-38175-G


6AG7 STATIC CHARACTERISTICS
SCREEN VOLTAGE = +100V
E_f = 6.3V AVERAGE OF 6 TUBES
DATA FROM ICWL 5-19
TESTS BY CWL
TESTS MADE 2/14/47
ENGINEER IN CHARGE: LDW
I_b OR I_{c_2}, MILLIAMPERES
60
50
40
30
20
10
0
0
25
50
75
100
125
150
E_b IN VOLTS
I_{c_2}
0
-1
-2
-3
-4
USE

2

C CHARACTERISTICS
OLTAGE = +100V
AVERAGE OF 6 TUBES

M ICWL 5-19
CWL
DE 2/14/47
IN CHARGE: LDW



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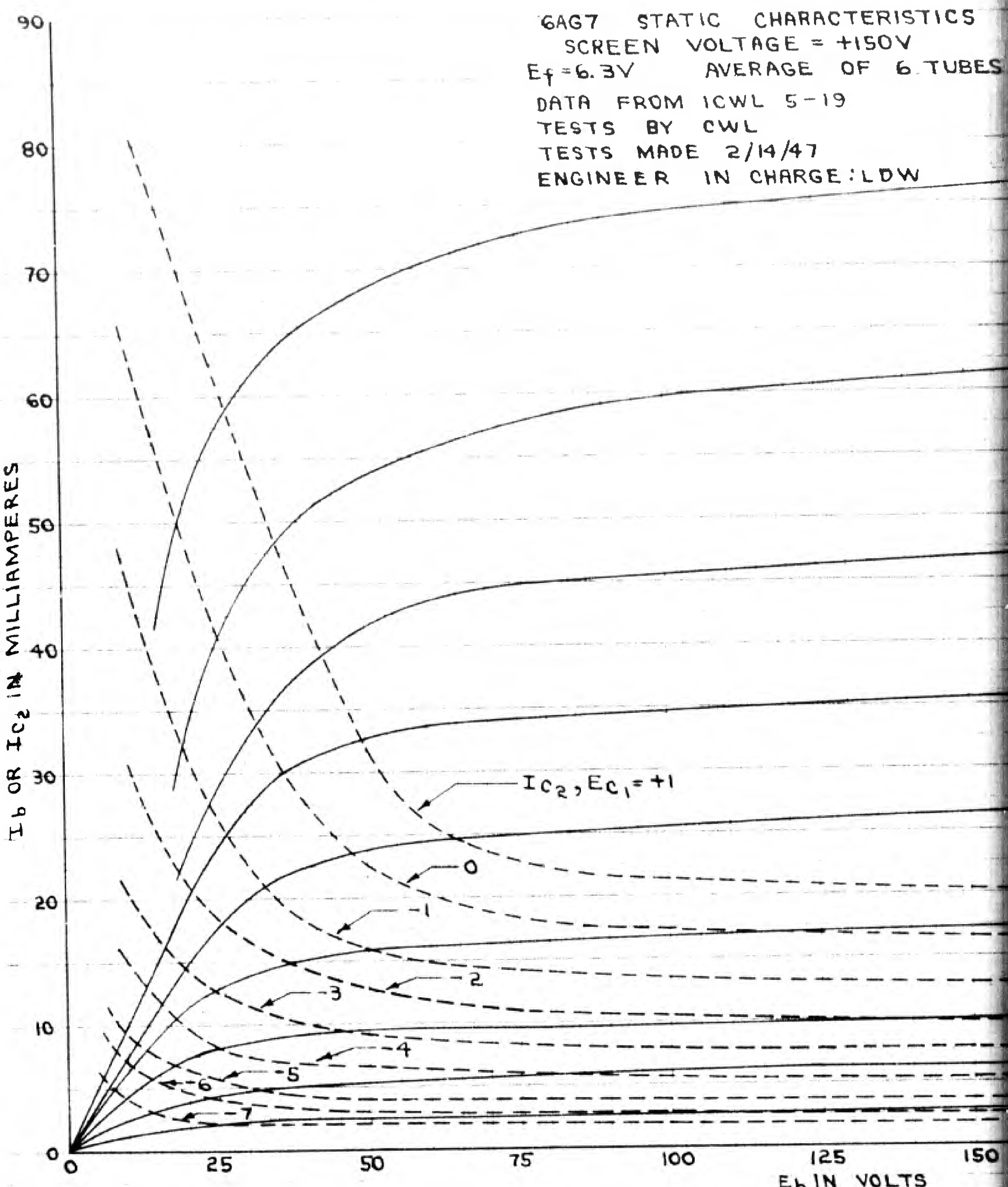
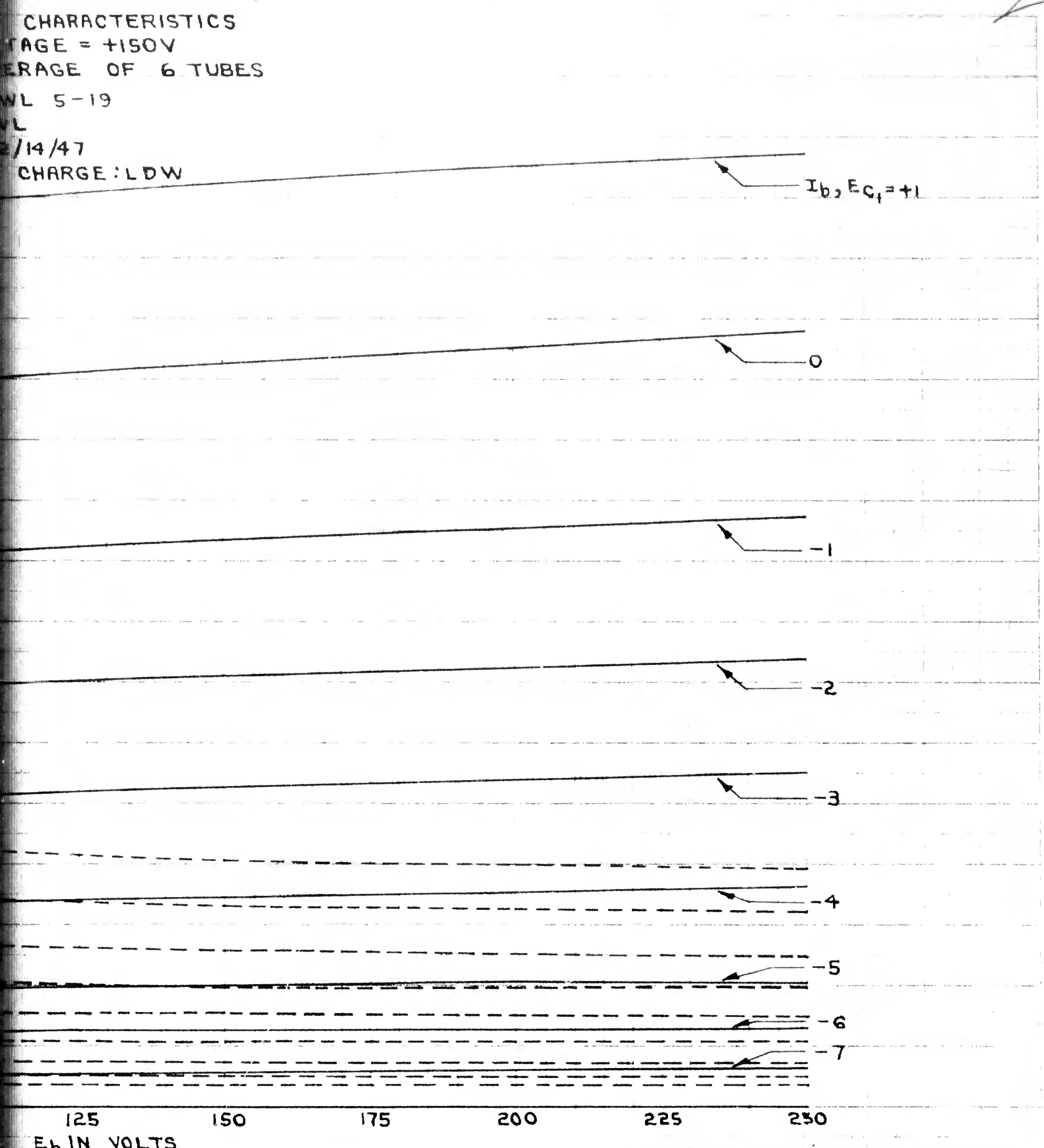
6345 D.L.O. 2-27-47 3/1/47

L.D.W. B-38176-G



6AG7 STATIC CHARACTERISTICS
SCREEN VOLTAGE = +150V
Ef = 6.3V AVERAGE OF 6 TUBES
DATA FROM ICWL 5-19
TESTS BY CWL
TESTS MADE 2/14/47
ENGINEER IN CHARGE: LDW
Ib OR Ic2 IN MILLIAMPERES
Eb IN VOLTS
Ic2, Ec1 = +1
0
-1
-2
-3
-4
-5
-6
-7
0
10
20
30
40
50
60
70
80
90
25
50
75
100
125
150

USED IN



USED IN 6345 REPORT R-118

6345 D.L.O. 2-27-47 TL 3/1/47

LDW

B-38177-G

6345
Memorandum M-119

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

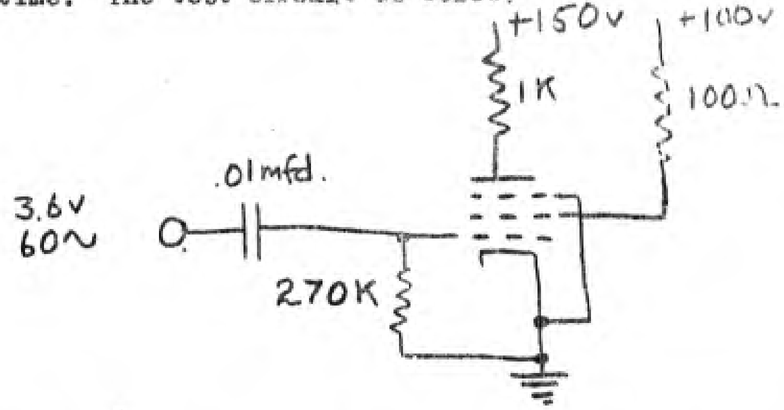
SUBJECT: 6AG7 LIFE TEST RESULTS AND REVISIONS

To: J. W. Forrester, H. Fahnestock, H. R. Boyd, N. H. Taylor, D. R. Brown, N. Rochester (Sylvania), D. Stevens (Sylvania), F. Anderson (Sylvania).

From: R. L. Best

Date: October 21, 1947

After running 1650 hours, the data from the 6AG7 life test, at Sylvania, has been analyzed. The rack holds 100 tubes, 21 of which had supposedly failed at this time. The test circuit is below:



The .01 mfd. coupling condenser has a reactance of 270K at 60 cycles, this representing quite a high impedance driving circuit. A Ballantine voltmeter was connected from plate to ground, measuring the output voltage. The 3.6 volt r.m.s. signal is 10.2 volts peak to peak, and it was thought that this would be sufficient to drive the tube from cutoff to zero bias. However, the coupling condenser is so small, that the actual grid voltage is only .95 to 1.4 volts r.m.s., depending on the tube. Alternately turning the tube on and off would make the a-c plate voltage a measure of the emission of the tube; but with this small grid signal, due to the high impedance driving circuit, the output voltage is mostly a measure of how much the tube loads its own grid circuit.

The end of life point was specified as the time at which the output voltage dropped to 70% of the output voltage at 27 hours. The first 14 failures, according to this specification, were retested, and it was found that their average emission was 78% of the average emission of 12 used tubes selected at random, and 85% of the average emission of 14 new tubes. This shows that the failures weren't failures at all. Not one of the 14 had its emission below 70% of the average emission of the new tubes, while one had a higher emission than the average of the new tubes. Emission was measured in the above circuit by grounding the control grid, and measuring the drop across the plate load resistor.

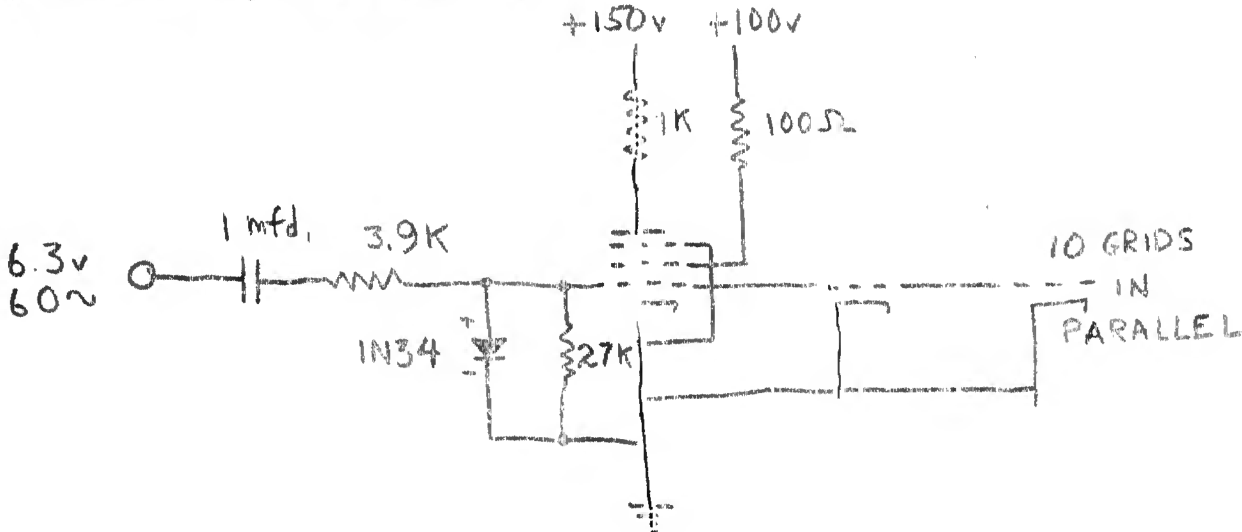
The first 14 failures were set up in the same circuit as was used in the life test, and it was observed that, during the first ten minutes of operation, the average output and the average signal appearing on the grids both dropped 15%. This gave the appearance of having the tubes apparently age 1000 hours in ten minutes.

One tube was set up in the test circuit with 6.3 volts on the filament, the output being 8.8 volts. After 10 minutes, it had leveled off at 8 volts. Then the filament voltage was suddenly dropped 10% to 5.67 volts, the output voltage dropping to 6.7 volts in .2 seconds, then rising gradually to 7.7 volts, after 30 minutes. When the filament voltage was restored to 6.3 volts, the output rose to 8.7 volts in .2 seconds, then gradually dropped off to 6.7 volts in 30 minutes. Then the filament voltage was suddenly increased 10% to 6.93 volts, the output voltage dropping to a minimum of 2.2 volts at 3 minutes, gradually increasing to 4.2 volts after 50 minutes, and still slowly rising. When the filament voltage was restored to 6.3 volts, the output voltage gradually increased to 7.2 volts, after 50 minutes.

These wide variations in output voltage with filament voltage, due more to grid loading effects than changes of emission, explain the inconsistency in the data taken during the life test. Curves of output vs. time for a given tube often show deviations of ±10% from a smooth curve.

In the above circuit, half the first fourteen appeared more or less microphonic, with one apparently having something loose inside, jumping between various output voltages as it was tapped. When driven from a stiff source, however, only two tubes were at all microphonic, neither of which were the one that previously appeared loose inside.

Increasing the coupling condenser from .01 mfd. to .1 mfd. is satisfactory, and the addition of a clamping diode eliminates variations in self bias with filament voltage. A 39K resistor added in series with the capacitor, clips the sine wave nicely, so that plate waveform is close to a square wave. Increasing the signal from 3.6 to 6.3 volts further insures that the tubes will be cut off and on every cycle. The modified circuit is below, with the impedance level reduced by a factor of 10, so that 10 grids may be driven in parallel by a single circuit.



Measurements will be made on the rack every Monday, Wednesday, and Friday. These measurements shall consist of 10 a-c grid voltages, one at each of the 10 sets of 10 grids in parallel, as well as the a-c plate voltage at each of the 100 tubes. Before each measurement, filament and signal voltages should be set at 6.3 volts, plate supply voltage at 150 volts, and screen supply voltage at 100 volts. For a given tube, end of life shall be reached when its output voltage drops to 70% of its initial output voltage.

The tubes now in the life rack shall remain there; after data has been taken on them for two weeks, the results will be reviewed to determine a means of comparing the two different sets of data.

Signed R. L. Best
R. L. Best

RLB/sp

6345
Memorandum M-128

Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: SUPPLEMENT TO MEMORANDUM M-119; 6AG7 LIFE TEST RESULTS

To: J. W. Forrester, H. Fahnestock, H. R. Boyd, N. H. Taylor, D. R. Brown, N. Rochester (Sylvania), D. Stevens (Sylvania) F. Anderson (Sylvania)

From: R. L. Best

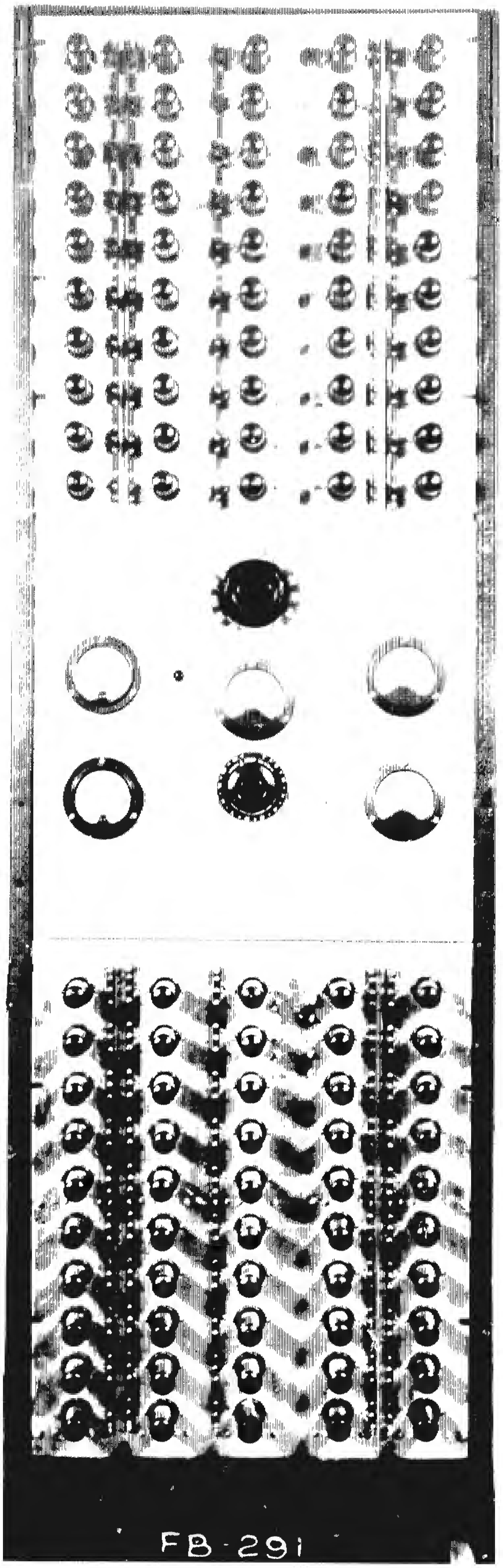
Date: October 28, 1947

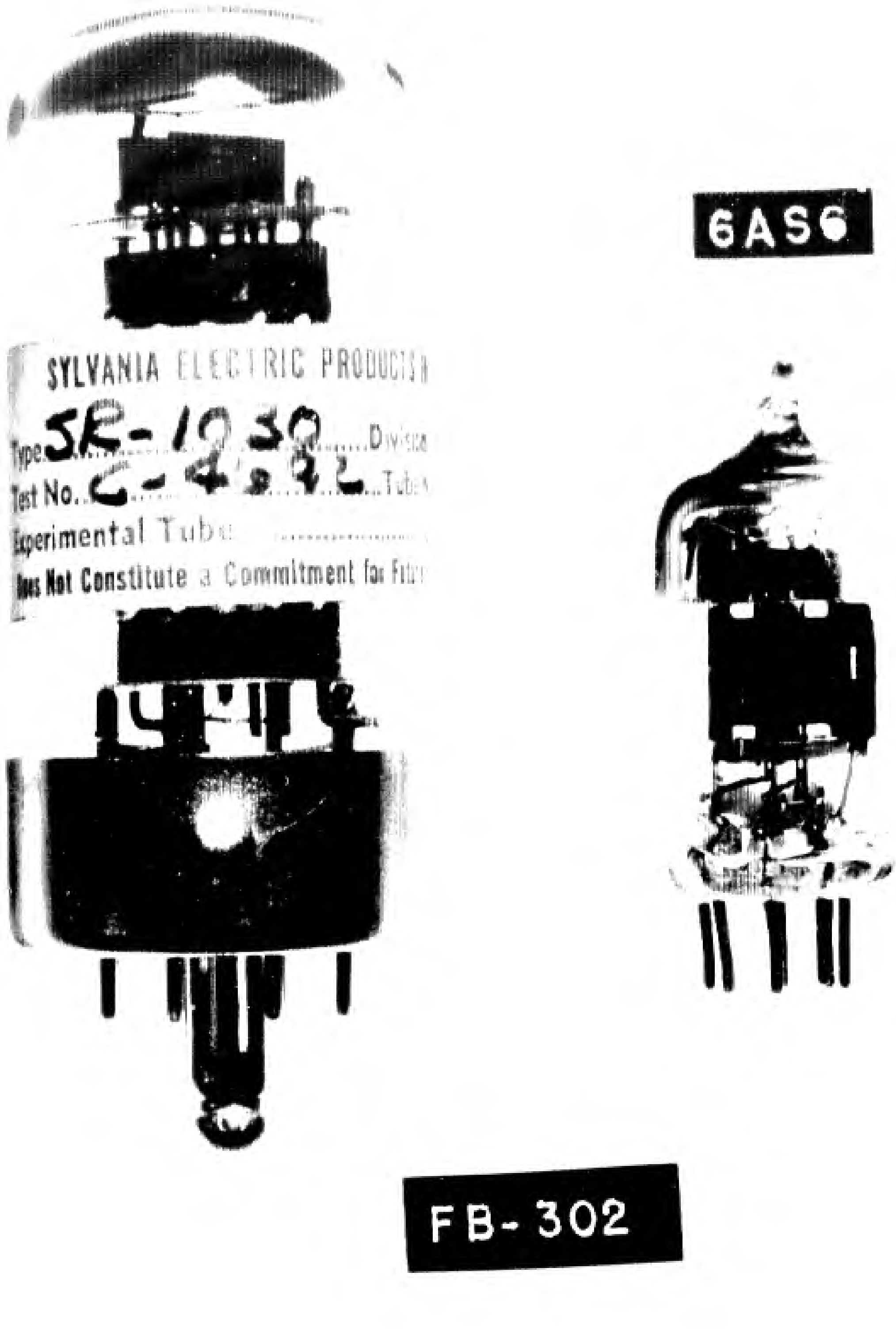
The first 27 tubes in the 6AG7 life test rack that failed, according to specifications set forth in Engineering Notes No. E-43 have been tested for emission. This was done by grounding the control and suppressor grids, supplying the screen with 100 volts through 100 ohms, supplying the plate with 150 volts through 1000 ohms, and measuring the d-c drop across the plate load resistor. The average emission of these 27 tubes was 32.4 m.a. while the average emission of 14 new tubes was 36.0 m.a. The ratio of the emissions of the failures to the new tubes was 90%. Not one of the failures had its emission below 70% of the new tubes' emission.

Since no emission measurements were made on the life test tubes at the beginning of the run, it is hard to say whether any tube's emission has dropped to 70% of its initial value or not. However, the measurements just made do indicate that the greatest number of the failures weren't failures at all, but that their drop in output was primarily due to grid loading effects (see M-119).

Signed: R. L. Best
R. L. Best

RLB/sp


FB-291


SYLVANIA ELECTRIC
Experimental Tube
6AS6
FB-302